

Metallurgical & Chemical Engineering

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Two Necessities in Flotation

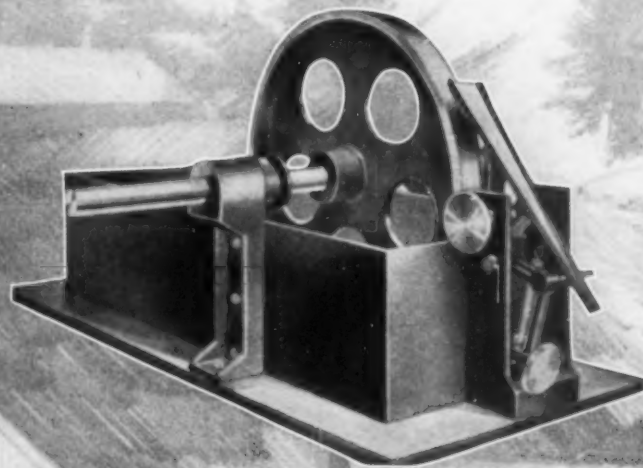


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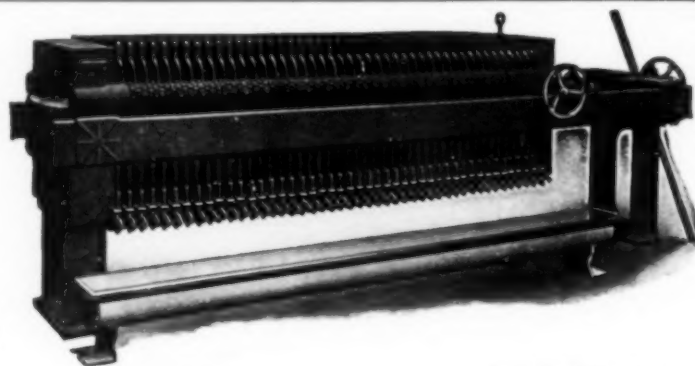
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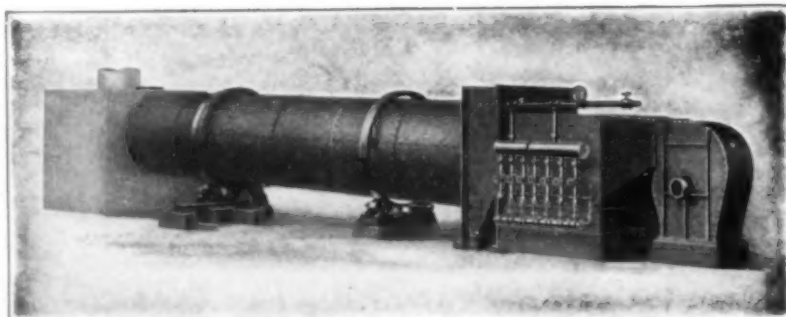
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Contents for April 15, 1917

EDITORIAL:

The War	413
Steel in War	414
A Suggestion on Fire Brick	414
Switzerland and the Chemical Industry.....	415
The Late David H. Browne.....	415

READERS' VIEWS AND COMMENTS:

Methyl Alcohol and Acetone as By Products of the Soda Pulp Industry. By Jas. C. Lawrence.....	416
Ball Mills. By H. W. Harding.....	417
Vanadium Check in High-Speed Steel Analysis. By Ed- ward C. Kraus.....	418
Coming Meetings and Events.....	418
Big American Dyestuff Companies Merge.....	418
The Western Metallurgical Field.....	418
The Training and the Work of the Chemical Engineer. (Sym- posium before the Faraday Society).....	420
Preparedness Census of Technical Men.....	422
The Late David H. Browne.....	423
Annual Meeting of the American Chemical Society at Kansas City	423
Exfoliation and Carbon Concentration in the Case Hardening of Steel. By Edwin P. Stenger.....	424
Electrical Porcelain. By L. E. Barringer.....	433
Beet Molasses: Its Composition and Utilization. By Sidney J. Osborn	436
Another Tin Smelter for the United States.....	443
Some Studies on the Methods of Recovering Antimony from its Ores. By Volatilization Processes. By J. A. DeCew....	444
Grading of Crushed Stone and Gravel, Feldspar, Fireworks and flour. By Edward S. Ward.....	449
RECENT CHEMICAL AND METALLURGICAL PATENTS.....	452
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERA- TURE	453
Hydroelectric Exhibit of Canadian Pacific Railway.....	455
New Electrocyanide Process	456
BOOK REVIEWS	457
PERSONAL	457
Current Market Reports—Iron and Steel Market, Non-Ferrous Metal Market, Chemical Market and Price List.....	457
Industrial—Financial, Construction and Operation and Manu- facturers' Notes	461

The War

The United States is at war with Germany. The ulti-
mate object is a world peace founded on liberty and
justice and the war is the price of such a future peace.
Now that the United States is engaged in the mighty
conflict, a united American nation stands solidly behind
the President, and there is one pledge in every one's
heart: "My Country."

From the President's address to Congress we quote:
"We are at the beginning of an age in which it will be
insisted that the same standards of conduct and of re-
sponsibility for wrong done shall be observed among
nations and their governments that are observed among
the individual citizens of civilized states. We have no
quarrel with the German people. We have no feeling
toward them but one of sympathy and friendship. It
was not upon their impulse that their Government
acted in entering this war. It was not with their pre-
vious knowledge or approval. It was a war determined
upon as wars used to be determined on in the old un-
happy days when people were nowhere consulted by
their rulers and wars were provoked and waged in the
interest of dynasties or of little groups of ambitious
men who were accustomed to use their fellow men as
pawns and tools."

* * *

The President's safe and sane advice to this country
to keep a level head on our shoulders is as true and
important today as when it was made at the start of the
war in 1914. It is particularly fitting for American en-
gineers and chemists. Suddenly they have become in a
large measure the trustees of the country's safety.
Having been the upbuilders of the country they now be-
come its defenders. Much has already been done dur-
ing the past year under the leadership of the Naval Con-
sulting Board and the Council of National Defense.
Very valuable work has been done by the different en-
gineering and chemical societies in the preparation and
compilation of data showing the industrial strength of
the various industries and providing exact knowledge
of what any manufacturer can do. But very much
more remains to be done, very much more earnest think-
ing and very much more solid action.

But thinking must precede action, otherwise there
will be chaos. As an example, we have already urged
that chemists who can do productive work in making
munitions should be restrained from enlisting to serve
with the colors. It is patriotism turned upside down
for a young man who is familiar, for instance, with
nitration processes, to march behind the band. The
place where he can serve his country most efficiently is
right in the works and in the laboratory. We do not
mean that every drug clerk should be freed from the

obligation to go to the front, but research and works chemists and chemical engineers are needed more keenly now than ever before in their profession, for their country's sake.

Likewise, the *Engineering and Mining Journal* is right in recommending mining men not to be too quick in volunteering for the army, but to wait for the special call for recruits for mining and tunneling companies. We should profit from the experience in Great Britain. When it was found there that sappers and miners were needed, it was also found that many of the experienced men were already at the front with the infantry and cavalry, and it was hard to get them out, but it had to be done.

These are just two examples showing that it is not enough to call out the fighting force of the country, but that it is just as important to see to it that each man is placed at the right place—not where he would like to be, but where the country needs him most. What is needed, in one word, is organization, not only of the men but of the industries and of the natural resources of the country. And organization of the whole requires unselfish service and devotion all around. The big metallurgical industries of this country have seen their duty and are doing it in placing war metals at the country's disposal at cost price. More than one chemical manufacturing plant that expects to be taken over by the Government as a whole is straining every nerve to deliver a working unit of highest efficiency and deepest loyalty. And so all of us must stand ready to serve our country with hearts and heads and hands and fortunes.

Steel in War

The United States enters the world war making steel ingots and castings at the rate of about 45,000,000 tons a year. When the war started the Central Powers had a capacity of about 22,000,000 tons, while the capacity of the United Kingdom, Canada, India, France, Belgium and Russia was a trifle less, and this capacity has been since materially reduced. Italy entered the war, it is true, with a capacity of about 1,000,000 tons, and England's capacity has been increased, but the Entente Allies lost all the Belgian capacity and most of the French, while it seems that Russia has not been able to operate at more than about two-thirds capacity. The Central Powers have hardly operated their original works at capacity, though they have probably gained considerable production in the occupied territory. At any rate the American capacity added on the side of the Entente Allies is overwhelming. We can make a much greater tonnage of steel than we can fabricate into things useful for war purposes, and it is in that direction that the strain will come. The supply of crude steel will take care of itself.

It was early recognized that this was a war of steel. Now it is a war of the steel nations. Save the Balkan states, and Portugal, which is only nominally in the war, there is not a country engaged in the war that has not a steel production somewhat commensurate with its

population. This appears a rather significant fact.

Of the remaining neutrals there are only two having steel production equal to that of even a modest-sized American works, Sweden, with a capacity of perhaps 600,000 tons, and China with perhaps 150,000 tons. Less than 1 per cent of the world's present steel production, which is running in the neighborhood of 85,000,000 tons a year, is being produced by nations at peace. Whatever may be the ability of the belligerents to rebuild and refurnish when the war ends, the neutral countries will certainly have to find means to buy a great deal of steel, for they can get very little at present.

For efficiency "all place a temple and all season summer" but this is a particularly ripe time for American efficiency. As to steel it is a question of finding means to fabricate as much as possible to the uses of war, when the supply of crude steel is virtually unlimited and some of the channels through which it flows into final form are painfully restricted. For much more than a year the plate mills have been congested with tonnage, most of the plates being wanted virtually for war purposes, so that it is not a case of setting an unimportant customer back that an important customer may be served.

When the final limit of the fabricating capacity for steel is reached, American ingenuity must find other patterns, equally useful, to make instead. If the shipyards are congested with the work of building vessels of the regular type, other types of vessels must be developed, that can be built with less equipment, using, if possible, rolled forms of steel that are not in acute demand for war purposes. The tube form is the strongest disposition of matter. Perhaps steel pipe, or certain merchant mill products, can be combined with wood for constructing vessels rapidly without the elaborate layout of the conventional shipyard.

From the "flivver" to the 60 or 80 miles an hour road burner our automobile factories are turning out internal combustion engines to the tune of more than 50,000,000 hp. per year, a magnificent factory equipment from which to draw engines that should be adaptable to thousands of small vessels for merchant, scout and other purposes. We have the iron, the steel and the equipment; it is a question of efficiency to develop and build from what we have.

A Suggestion on Fire Brick

Since the founding of this journal in 1902 it has ever tried to act as an intellectual clearing house for the metallurgical and chemical industry. Starting in the special domain of electrochemistry, it found at once one allied field of special importance thereto. This was the field of refractories, for in electric furnace work special brick must be used. In the abnormal period in which we have all lived in the past three years, an abnormal and unusual strain has been put on the manufacturers of refractories. Good and uniform clay deposits are not frequent. Furnaces have been "fired hard." Coal has been poor. Firebrick has sometimes been of poorer quality for these reasons and because it is so largely

a question of labor. All makes for an excess of consumption over production.

Such all being so plain as to rival the foremost feature of one's face, it seems that something must be done now. We venture a suggestion. We know that aluminium silicate when pure is a fine refractory. We also know that the fusible impurities of ordinary fire clay, viz.: Fe_2O_3 , CaO , Na_2O and K_2O are soluble in dilute hydrochloric acid. We further know that the advance in the state of the art in leaching and filtering is such that it is cheap and efficient from every standpoint on a basis of from 100 tons to 1000 tons per day.

Why not, then, leach, wash fireclay and so extract the impurities to a substantial degree? This would equalize impurities by large-scale mixing of the clay. The slight gelatinization of the silica would increase binding properties. The quality of bricks so made would be immensely improved and in short a firebrick of a very fine grade would be made.

In this age of hustle, bustle and worry quick results are needed. We recommend to one who can see this duty to do it. Firebrick and refractories having been a favorite field of this journal for many years, we believe that, to quote the words of the immortal Governor Jeremiah Rusk, in publishing this suggestion, "we seen our duty and we done it." But as a friend of the said governor stated, "It is a condition and not a theory that confronts" the firebrick manufacturer.

Switzerland and the Chemical Industry

In looking over the output of chemicals by Switzerland for the last two years, one wonders how under present circumstances it has been possible for any European country to show an increased output in any field of industrial manufacture outside of war supplies. And yet the export figures of Switzerland for the years 1914 and 1915 compare as follows:

	1914.	1915.
Chemicals for industrial purposes.	\$3,516,742	\$5,887,067
Paints, dyes and colors.	6,232,660	6,443,548
Pharmaceutical products, drugs		
perfumery	3,100,163	4,747,680

With only very few natural resources, the chemical industry in this small heart of continental Europe has steadily increased. Considering that salt, lime and asphalt are about all the raw materials available in Switzerland, the above figures are all the more remarkable. All other raw materials must come from the warring nations. This actually is the case; Germany supplies iron and coal, while England, Italy and France furnish most of the other raw materials.

There are two well-defined reasons why in the industrial field Switzerland is progressing in spite of the war: First, because it has a well-organized government whose sole ambition is the welfare of the country, and secondly because it would be of no advantage for either of the belligerents to antagonize Switzerland, as it has one of the most efficient armies in Europe.

Switzerland without its industries would undoubtedly starve or be forced to side with one or the other warring factions. While the Swiss industry as such is

undoubtedly developing very rapidly, the increased export values are, to a great extent, due to the fact that the other countries are exporting less of the same products.

The Late David H. Browne

"There are in every profession men whose personality and accomplishments raise them above the level of their colleagues and they in turn raise their profession to new standards and their confreres to their own level. . . . Such men create a new horizon, envisage large ideals, invest old things with a new meaning."

This quotation from David H. Browne's recent Mining and Metallurgical Society address on H. C. Hoover's work may well be applied to David H. Browne's own life that was cut short by an untimely death on March 30. In the obituary notice on another page of this issue mention is made of his two big metallurgical achievements—the development of his electrolytic process for separating the copper and nickel in Sudbury ore and the successful reduction to practice of powdered-coal firing of reverberatory smelting furnaces.

David H. Browne was a truly great metallurgist but he was even greater as a man and no one who once had the privilege of meeting him will ever forget him. The wonderful combination of straight common sense with lofty idealism, often flavored with quaint Irish humor, which was so characteristic of Browne as man, found vivid and true expression in the addresses made by him—a minister's son—on many a festival occasion.

From an address delivered by him before the Engineering Society of Queen's University in 1912 (this journal, vol. X, p. 393) on the real objects of university education—culture, friendship, inspiration—we quote the following passages:

"Culture, friendship, and inspiration, these three, and the greatest of these is inspiration. This is the one thing which all the others lead to, for this is the true vision. Inspiration means the inbreathing of a great spirit, the breath of fire in man's nostrils. We cannot define it, we cannot analyze it, we can only feel it as we feel a chord of music. It comes from the consciousness of the presence of the mighty dead who have molded the nation, it comes from the companionship of noble men and women living around us, from the memories with which the college halls are hallowed. You know the feeling that comes over you in a close-packed crowd when the leader arises and you see the tense upturned faces around you and hear the quick intake of breath, as the truth he speaks sinks home. You picture the gaunt figure of Lincoln at the National Cemetery and the hushed audience that hangs on his words as he gives them the greatest speech ever made in the English language, the matchless Gettysburg address. They turn away too deeply moved to applaud, too much uplifted to cheer, because they have received the inspiration, they have seen the vision."

David H. Browne has gone. But he is still with us: we have received the inspiration, we have seen the vision.

Readers' Views and Comments

Methyl Alcohol and Acetone as By-Products of the Soda Pulp Industry

To the Editor of Metallurgical & Chemical Engineering

SIR:—The publication of the interesting article by Professors White and Rue in your issue of Feb. 15 on the recovery of products from black liquor by destructive distillation coincides with the commercial development of a similar process which is now taking place in this country and on the Continent.

The peculiarity of the black liquor obtained at the mills here is, of course, that they are all obtained from cooking Esparto—no soda wood pulp being produced here.

A general outline of the complete process as used in handling the black liquor from the time it is drawn from digestors is as follows:

1. Continuous film evaporation in a "multiplex" triple effect where the liquor is brought to about 25 to 26 deg. Bé.
2. Evaporation in a pressure finishing evaporator to 38-40 deg. Bé., the vapors being used to partially operate the "multiplex" at 7 lb. back pressure.
3. Black syrupy liquor from finishing evaporator incorporated while hot with a measured quantity of lime hydrate and run into trays to the required depth.
4. Trays loaded on to trucks and placed in horizontal retort for carbonization.
5. Leaching the carbonaceous residue and recovering soda.

The theoretical process covering the production of acetone and wood alcohol by destructive distillation of black liquor mixed with lime was patented, we believe, by Dr. Rinman of Stockholm, whose experiments on both laboratory and commercial scales have proved the feasibility of the chemical manipulations and changes involved, so that the matter of constructing commercial equipment for carrying out the process most economically and to enable the operations to become profitable lay with ourselves as makers of chemical plant.

The patentee had constructed various sized units on the Continent for experimental processes, the most successful from an operating standpoint being a retort in the shape of a cone, down the sides of which the liquor flowed in a film, the carbonized mass being scraped off from time to time.

We, on the other hand, had built several plants for the production of acetone by the distillation of calcium acetate and knew the conditions under which most favorable results were obtained there. We had also built many plants for carbonizing wood to produce wood alcohol, and were acquainted with suitable conditions of operation in this work. We decided, therefore, to adopt our standard design of acetone plant from calcium acetate, to the carbonization of lime-black ash distillation.

It was necessary to limit the thickness of the layer of lime-black ash in each tray on account of its tendency to froth, but once the maximum thickness allowable was arrived at the determination of time and temperature required for distilling charges of several tons was a simple matter.

I notice that Professors White and Rue do not make reference to any peculiarity of their "tar" as obtained from wood pulp black liquor. One of the most interesting products from Esparto black liquor is the "tar" or the equivalent of tar. In reality the "tar" obtained in this case is a light brown wax which is quite hard

when cold, resembling greatly the "Candelilla wax" obtained from a plant (*Euphorbia antisiphilatica*) grown in Texas.

The condensation, therefore, of the wax and the separation of aqueous condensate from it, as well as the absorption of the ammonia produced in the distillation presented a unique problem. The difficulty was overcome by fractionally condensing the wax in a "pre-condenser" at approximately 200 deg. C., and allowing it to drain off in a molten state. The middle oils were fractionally condensed at 110 deg. C. and drawn off. Fortunately the oily wax seems to be a very homogeneous substance, practically all condensing at the two temperatures, allowing all the aqueous vapor with acetone, alcohol and ammonia to pass to the absorber where the latter is absorbed in sulphuric acid, the water alcohol and acetone going on to the final condenser.

The refining of the products is only carried to a point which makes them salable. The wax is drained and shipped as pressed cakes. The sulphate of ammonia liquor is shipped in casks to the tar works for evaporation. The acetone and alcohol are merely rectified together without attempting a separation, until a water-white miscible liquid is obtained testing about 95-97 deg. on Tralles hydrometer. This is marketed direct as "methyl-acetone" or "alcohol-ketone" for cellulose acetate solvent, etc.

As a matter of fact, it is doubtful if the amount of actual acetone as such produced is anywhere near the amount apparently present or determined by iodoform test. The "acetone" indicated in the mixture by the iodoform determination consists probably in large part of other ketones. We have never been able by the ordinary methods of rectification or chemical treatment to separate pure "Government Specification" acetone for explosive use from this product.

A description of the general arrangement of the retort and condensing plant may be of interest. The point of taking out the vapors from the retort was arrived at by trial, the point selected being the *coldest* part of the entire furnace. Ample arrangements are provided for pyrometer measurements at various points. Heat distribution and circulation *inside* the retort are provided by injecting a small amount of superheated steam at the correct temperature so that it comes in actual contact with the trays and their contents, sweeping the entire length of the retort to the exit pipe.

The working temperatures arrived at for maximum yields are below the limits of 288-316 deg. C., suggested by White and Rue, viz.: 255 to 300 deg. C.

The above results and conclusions are the result only of data obtained to date, and these statements should be considered as tentative only, as further data are being collected for a series of experiments which should indicate the effect of varying several factors in the process. We are of the opinion that the present yields must be increased by some 50-75 per cent to approach the theoretical, so there is room for a great deal of investigative effort in this connection.

BLACK LIQUOR DISTILLATION

(Percentages on actual liquor without lime)

Watery distillate	42.2 per cent
Wax and oils.....	6.0 per cent
Ammonia	0.3 per cent
Residue	40.7 per cent as black ash only
Gas	10.8 per cent

Watery distillate: Spirit content, 5.24 per cent.

Spirit test: 70 per cent methyl alcohol; 30 per cent acetone, ketones and aldehydes.

Wax and oils: Wax, 39.2 per cent, condensed at 200 deg. C in pre-condenser.

Middle oils, 56.5 per cent, condensed at 110 deg. C. in second condenser.

Light oils, 4.3 per cent, condensed with watery distillate.

From our results to date we seem to be in agreement with the essential points of Messrs. White and Rue's chemical and financial deductions in so far as the two raw materials allow of direct comparison. Their credit of methyl alcohol and acetone mixture of 95 per cent strength at a pre-war price of only 40 cents per gallon is most conservative, as the writer was selling similar material in the U. S. A. at 60 cents naked at works in 1913-14. With the production of wax instead of tar the income in Great Britain is considerably increased, but we are of the opinion that the tar as produced from wood liquor containing upwards of 50 per cent phenols, as stated, should bring a good price raw, but better if worked up at the factory.

On the whole, our experience so far leads us to believe that in the U. S. A. the figure of \$1.86 net saving per cord of wood treated in the digester should be slightly exceeded in normal times. At the present time, of course, with products bringing abnormal prices, the net return should be considerably above that.

JAS. C. LAWRENCE.

Blair, Campbell & McLean, Ltd.,
Glasgow, Scotland.

Ball Mills

To the Editor of Metallurgical & Chemical Engineering

SIR:—Referring to the publication in your issue of March 15 of the informal paper by Mr. Marcy on "Marcy Ball Mills" read at the February meeting of the Mining and Metallurgical Society of America, but not printed in the *Transactions* of the society, I am mainly interested in the errors and omissions of the article mentioned, and Mr. Marcy's remarks relative to the Hardinge conical mill, to which he refers as the "cone mill." I ask a little space, in justice, not only to myself, but to Mr. J. M. Callow, the Miami Copper Company, and the Inspiration Consolidated Copper Company, as well as the metallurgist who is seeking facts.

The Hardinge mill to which Mr. Marcy refers and which was used by Mr. Callow in 1912, was a 6 ft. diameter by 16-in. length of cylinder conical ball-pebble mill such as is now used for fine grinding only. The results of this work were open to observation of the Miami Company's engineers and were such that they conceived the possibility of replacing their fine rolls with Hardinge ball mills. The one referred to by Mr. Marcy was accordingly installed and a test run of approximately 25,000 tons of ore resulted in the opinion at that time that the rolls already installed were doing fairly comparable work, and the test was discontinued.

After continuing the operation of the rolls for over three years and gaining data through their operation, and comparing same with the results of their first test with the Hardinge ball mill—above cited, and finding it far superior to the work of the rolls for present requirements, they have recently placed an order for eight standard 8-ft. diameter by 30-in. cylinder Hardinge ball mills to take the coarse feed which at the present time is being fed to their secondary rolls. An action such as this, under the guidance of the Miami's critical engineering staff, who are seeking the highest efficiency, is an obvious recommendation and adoption of the system which Mr. Marcy points to as a "failure." It was a

failure at that time only because comparative data were lacking.

Still further emphasis is given to their opinion in view of the fact that the Miami Copper Company adjoins that of the Inspiration and both companies are working upon identically the same ore body. Further, the Inspiration Copper Company, after having presented to them data and the comparison of their work with Marcy mills and the work of the Hardinge mills at the Miami Copper Company, as well as other comparative facts and figures, are at the present writing installing Hardinge mills in the newest section of their plant. Up to the present time they have never previously had a comparison between the Hardinge ball mill and the Marcy ball mill, the latter equipped with 225-hp. motors, the motors absorbing approximately 240 hp. each.

These 8-ft. diameter by 36-in. cylinder Hardinge ball mills are being equipped with 150-hp. motors, will contain a greater charge of balls than the Marcy mill, but will operate with approximately 100 hp. less than is being absorbed by each of the Marcy mills now in operation. Relative capacities, horsepower, and general efficiency will no doubt affect the final decision and ultimate final reconstruction of the Inspiration plant. The management gave it as their opinion that we would require motors of equal size as those used on the Marcy mills (225 hp.). Upon showing them facts and figures they consented to the adoption of motors of 150 hp., which we consider to be ample for the requirements.

Mr. Marcy has overlooked in his paper information which was presented at the American Institute meeting in Arizona in 1916, relative to operating costs, including the consumption of chrome steel balls per ton of ore crushed. Permit me to supply the oversight and add the consumption of balls in the case of this "successful failure" (?) to use Hardinge conical mills. This ball consumption, however, should only be taken into account provided the comparison by Mr. Marcy can be made at all, which I do not believe to be the case and which I claim is unfair to all concerned, as all the grinding requirements should be considered:

	Chrome Steel Balls Per Ton Ore
Marcy Mills at Inspiration plant.....	1.79 lb.
Hardinge Conical Mill at Callow test.....	0.75 lb.
Hardinge Conical Mill at Miami test.....	0.58 lb.

As Mr. Marcy has undertaken to compare these "cone ball mills" at the Callow test plant at Inspiration, as well as the Miami plant, permit me to supply omissions and give below exact operating figures which I am ready to verify. These three mills were all working on the same class of ore, from the same general ore body, but in adjoining claims, and the ore was generally relative as to the size of feed and discharge. The following results are of interest to your readers:

	Horse- power	Tons Per Day	Tons Per Hp. Day
6 ft. x 16 in. Hardinge ball-pebble mill in Callow test plant.....	40	386	9.64
6 ft. x 16 in. Hardinge standard, ball mill in Miami test plant.....	36	351	10.03
Marcy No. 85 ball mill in Inspiration test plant	138	628	4.55

Mr. Marcy refers to "1100 tons per day" in his largest mill at the Inspiration plant, in which case the feed is slightly coarser than in the above mentioned tests. We are also able to supply Mr. Marcy's omission as to the power required by this mill:

	Horse- power	Tons Per Day	Tons Per Hp. Day
Marcy No. 86 ball mill.....	230	1,100 (?)	4.78

It is worthy of note that the Hardinge mill is approximately 100 per cent more efficient, measured in tons per

horsepower-day, than is the Marcy mill, based on Mr. Marcy's own figures and comparisons, but without data.

These and other data when presented to the Inspiration engineers, tabulated, and considered by them, have resulted in the installation of Hardinge ball mills in the last and newest section of the Inspiration plant, the operation of which has been delayed by the non-receipt of other machinery to complete the installation.

H. W. HARDINGE.

Hardinge Conical Mill Co.,
New York City.

Vanadium Check in High-Speed Steel Analysis

To the Editor of Metallurgical & Chemical Engineering

SIR:—The result of a vanadium titration according to Dr. Johnson's modification for high-speed steels can be rapidly and accurately checked by the following method:

Upon taking the final reading of the vanadium titration, immediately add an excess of permanganate solution and stir vigorously for half a minute to insure complete reoxidization of both the vanadium and the ferrous ferricyanide precipitate. Next add the standard sulphate solution at a rate of about one drop per second, stirring rapidly in alternate directions, until the last pink tinge disappears. This point is easily arrived at by a practiced operator, viewing the solution through the side of the beaker placed before a window. At the critical point the addition of one or two drops fades the last pink and leaves a clear yellow solution. At this stage take the reading and titrate as before.

The following checks obtained by the writer verify the accuracy of the method:

% V found	Check
0.91	0.92
.83	.83
.67	.67
.21	.23
.18	.16

In the first reduction of the chromium and vanadium, it is desirable to add at least 4 c.c. excess of the sulphate solution.

The addition of the iron solution for each of the titrations, should be made at the same rate of speed.

EDWARD C. KRAUS.

Dunkirk, N. Y.

Big American Dyestuff Companies Merge

The two largest dyestuff companies in the United States, the Schoellkoff Aniline and Chemical Works, of Buffalo, and the Beckers' Aniline and Chemical Works, of Brooklyn, have planned to consolidate under the name of the National Aniline and Chemical Company, Inc. The capitalization of the new concern is expected to be close to \$20,000,000.

The Schoellkoff Company is the oldest and largest of the American dyestuffs companies and has expanded rapidly since the outbreak of the war. It has an enormous plant at Buffalo, the output of which has been sold by the National Aniline and Chemical Company, of 100 William Street, New York. The Schoellkoff Company is capitalized at \$3,000,000 and controls the selling company which is capitalized at \$1,000,000.

The Beckers' Company has also expanded rapidly since the war and is at present capitalized at \$5,000,000. It recently concluded the purchase for \$2,500,000 of the Standard Aniline Products Company, which has plants at Newburg, N. Y., and Wappinger Falls, N. Y.

The consolidation is significant for the dyestuff industry in this country and should place the new company in a strong position to meet competition. It is also the intention to manufacture pharmaceuticals and photographic chemicals.

Coming Meetings and Events

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

The Western Metallurgical Field

Flotation in Canada

Oil flotation is on a solid footing in the Cobalt District of Ontario. At the present time five mills are in operation with an aggregate tonnage of 1300 tons daily. These mills are the Buffalo with a capacity of 600 tons, which started operation during the earlier part of October; the McKinley-Darragh, 100 tons, which began operation in July; the Northern Customs, 100 tons, operating since the beginning of November; the Dominion Reduction, 200 tons, working since the earlier part of December, and the experimental plant of the Nipissing, 300 tons, which opened operation in June. In addition to the mills mentioned, it is expected that at least two more installations will be operating within the month, namely, the Coniagas and the National. The daily output will be 150 and 75 tons respectively.

Cyanide

Sodium cyanide has now entirely replaced potassium cyanide for the recovery of precious metals in fumigating, plating, etc., the results proving equal if not superior to those obtained by the use of potassium cyanide. Another element of saving is the lower cost of transportation in so far as the cyanogen content of sodium cyanide is greater than that of potassium cyanide.

One of the chief producers of cyanide offers the following products for sale: Sodium cyanide, 96 to 98 per cent, with a cyanogen content of 51 to 52 per cent; sodium cyanide, 89 to 91 per cent, cyanogen content 48 per cent, and cyanide chloride mixture, sodium cyanide, 73 to 76 per cent, and a cyanogen content of 48 per cent. It is noted with pleasure that the sodium cyanide present is given as such, and not in terms of potassium cyanide, as has been customary.

Radium Plant in Colorado

The Schlesinger Radium Company of Denver, Col., has acquired interests in some of the leading radium-ore-producing mines in both Colorado and Utah. In 1915 this plant was in an experimental stage. Since then operations have developed steadily and at the present time the rate of production is three grams of radium element per year.

The company is developing several branches of its business, one being the successful production of the by-products of radium-bearing ores, namely the manufacture of vanadium and uranium compounds from carnotite ores. One of the most interesting features is the manufacture of radio-luminous paint. This material gives off light in darkness through the stimulating effect of radium. It is found permanent for all practical purposes. The paint will be used for illuminating the fig-

ures on watches, on clock dials and on house numbers. This product is turned over to the Cold Light Manufacturing Company of Denver, which is exploiting further uses for the material. The United States government is using the luminous paint on compass and aeroplane dials.

The research laboratories connected with the Schlesinger Radium Company are at present undertaking the very interesting work of establishing an actual standard for the luminosity of the luminous products. This work is needed badly in order to standardize the materials sold on the market and to prevent the marketing of substitutes which are valueless.

Tungsten

Tungstic Acid Made in Colorado.—Within the past year two companies have entered the field of manufacturing tungstic acid WO_3 in Colorado. These are the Tungsten Products Company and the Black Metal Reduction Company, both situated at Boulder. At the present time both companies forbid the inspection of their plants, and while one may surmise the processes used, no definite statements concerning them can be made.

The Black Metal Reduction Company is turning out 600 lb. of tungstic acid daily of a very high degree of purity. An interesting feature in the manufacture of tungstic acid by this company is that the product marketed is obtained by a straight process without further refining. It is unfused and its purity ranges from 99 to 99.7 per cent WO_3 . Only 0.25 per cent of the acid is insoluble in ammonia. It is worthy of notice that the product is very low in sulphur and phosphorus, the maximum permissible amount being 0.04 per cent of each. The analysis of some of the materials gave not the slightest indication of the presence of sulphur and phosphorus. The moisture content of the product is 7.2 per cent. The main impurities, occurring in minimal amounts only, are iron and manganese. The total output for a period well into the future has been contracted for by eastern brokerage concerns. Any tungsten-bearing ore or material is used as a starting point. At present tailings are treated which are bought on the basis of their tungstic acid content.

Little is known of the doings of the Tungsten Production Company beyond the fact that they are making tungstic acid and ferrotungsten. The latter product is made in an electric furnace and considerable attention is being paid to the production of a product with a minimum amount of carbon and with a high tungsten content.

Buying Tungsten Ores.—In Boulder County, Colorado, two schedules for purchasing tungsten ores are used, one being based on the tungstic acid content per unit and the other on the tungstic acid content per pound. The pound schedule is generally used; however, two of the largest companies, the Primos Chemical Company and the Rare Metals Ore Company, buy their ores by the unit content, paying \$10 per unit up to 40 per cent WO_3 . It is claimed that the latter scheme is more readily understood by the miner and offers him a better price. On the other hand, the users of the pound schedule claim that both schedules are about the same, the difference between the two being so small as to be negligible. The base of the price is a sliding scale depending on the mill saving. At present the base employed by one of the producers is \$15 per unit of 60 per cent WO_3 product.

No penalties are charged and no premiums are given. This condition is a source of annoyance to the mill man, as at times a mineral is present which increases the tungsten losses and reduces the grade of the concen-

trates. This mineral is known as "horn rock" in the district. In reality it is a jasper, the coloring ingredient of which is tungsten instead of iron. This mineral is very light and much is carried off during milling, nevertheless a certain percentage of the impure material enters the concentrates and lowers the grade of the same. The mill men are therefore in favor of penalizing ores carrying above a certain percentage of horn rock.

Company Reports

Tonopah Belmont Development Company.—In the thirteenth annual report of said company the following items are of interest: The Tonopah plant at Tonopah, Nev., has been in continuous operation throughout the year, that is from Feb. 29, 1915, to the same date 1916, on Belmont mine ores. During this period 165,157 dry tons of ore, containing 32,348,289 ounces of gold and 3,237,602.06 ounces of silver were milled. The average grade of the tonnage treated was 0.196 ounces of gold and 19.603 ounces of silver, or \$13.883 per ton. The gross value was \$2,292,943.06, calculated silver in bullion at 50 cents per ounce. The average value per ton was lower than the per ton value of the previous year, which was \$16.721, by \$2,838 per ton, or by approximately 17 per cent.

The average recovery of gold was 96.18 per cent, while that of silver was 91.69 per cent. The combined gold and silver extraction was 92.97 per cent as compared with 92.99 per cent for the last year. The tailings for the year averaged 0.0075 ounces of gold and 1.63 ounces of silver. This is equivalent to \$0.964 per ton as compared with \$1.168 for the previous year (gold calculated at \$20 per ounce and silver at 50 cents per ounce). The average daily tonnage treated over a period of 361 days was 457.5 tons.

The average direct milling cost was \$2.366 per ton, or \$0.210 per ton higher than the similar cost for the preceding year. The average indirect milling cost was \$0.316 per ton, or \$0.092 per ton lower than that of the previous year. The average total milling cost was \$2.682 as compared with \$2.564 for the same item the year before. The direct cost of production of the unit ounce of Doré bullion was \$0.13 as compared with \$0.104 for the previous year. The higher costs per ton and per ounce of metals produced were due to the smaller tonnage handled, and to the increased cost of chemicals and other supplies.

The Millers plant, at Millers, Nev., was operated throughout the year as a custom mill. During the year it treated 56,730 dry tons of ore averaging 0.309 ounces of gold and 25.01 ounces of silver. The gross value of the material treated was \$1,073,516.86. The gold recovery was 93.75 per cent, while that of silver amounted to 90.13 per cent. The combined extraction of gold and silver was 91.33 per cent as compared with 87.98 per cent for the year previous. The yearly total profit amounted to \$33,397.96.

The average direct milling cost was \$3.57 per ton as compared with \$3.796 for the preceding year. The average indirect milling cost was \$0.228 per ton, as compared with \$0.277 per ton for the year before. The average total milling cost per ton of \$3.798 shows a reduction of \$0.275 per ton from the similar cost of the previous year. The direct cost of production of the ounce of Doré bullion was \$0.156, showing a reduction of \$0.006 per ounce over the same item of last year. The increased recoveries and decreased costs were due almost entirely to the installation of the continuous decantation system during the previous year. The cost of this installation amounted to \$24,930.10, which was completely refunded during the course of the year.

During the year 1,018.07 tons of "sweepings" have

been recovered under a leasing system, from the impounded Tonopah tailings. The average value per ton of this material was 0.343 ounces of gold and 55.92 ounces of silver, or a total gross value of \$34,328.28. The net returns from the "sweepings" was \$4,836.21. Because of the exorbitant smelter charges on this fine material the company has decided to erect a small mill to handle the product, as it cannot be treated satisfactorily in connection with the ores handled at the mill. The cost of this small plant will be less than \$10,000.

The Training and the Work of the Chemical Engineer

Symposium Before Faraday Society

The Training and Work of the Chemical Engineer was the subject of a symposium of papers and general discussion before the Faraday Society in London on March 6, 1917.

Sir Robert Hadfield, president, was in the chair, and in introducing the subject he indicated how wide a field of work was covered by the industrial chemist, and therefore early in his training he should begin to branch off into the line of work with which he would afterwards be associated. After giving some amusing personal incidents illustrating the kind of early training he himself had received, the president made reference to what was now being done in Great Britain by the government to aid industrial research. Finally, he outlined the scheme recently proposed by the Ramsay Memorial Fund for promoting chemical training and research in memory of one of the greatest English chemists, a scheme which included the establishment of a Ramsay Memorial Laboratory for dealing with the very subject they were discussing, namely, engineering chemistry.

THE FUNCTION OF CHEMICAL ENGINEERING

Sir George Beilby presented the opening address in the symposium. At the outset he referred to the great danger that war conditions might encourage the development of unbalanced proposals for the training of the future leaders and workers in industry. Free exchange of opinion should be proof against such a danger.

He then defined the subject as follows: *Chemical engineering has for its function the design and construction of apparatus required for the carrying out of chemical processes on a manufacturing scale.* Carefully distinguishing between the work of the research laboratory, of the process control laboratory, and of the works proper, and remarking that laboratory training alone tends to produce a certain narrow individualism, he summarized as follows a scheme for the training of chemists for industry:

1. A sound and practical training in chemistry and chemical physics extending over three years. During the third year special subjects to be introduced.
2. At the end of the third year at latest the case of each student to be considered by the heads of the departments, so that he may be advised in what direction he should specialize.
3. Average students with no special bent to complete their course by general advanced studies during the fourth year.
4. No degree or "hall-mark" to be given in chemistry till the complete four years' curriculum has been taken.
5. Chemical engineers, research chemists, and specialists in other branches to devote one or two years to higher post-graduate study.

He next illustrated the special engineering knowledge and experience required by the chemical engineer, due

to the wide variations in the conditions under which chemical processes take place. Finally, he defined the difference between the point of view of the chemist, who viewed matter as made up of molecules, and of the engineer, who dealt with matter and energy in the mass. As the point of view of the engineer was not so far removed from that of the ordinary intelligent person, it was often very difficult for him to look at chemical problems from the chemist's standpoint. Hence it was wiser first to imbue the mind of the student with the more difficult, because less ordinary, point of view.

THE TRAINING OF THE CHEMICAL STUDENT FOR WORK IN THE FACTORY

Professor F. G. Donnan, in speaking on this subject, classified chemists as follows:

CLASS I. *Chemists* (Research Chemists).

CLASS II. *Engineer-Chemists*.

CLASS III. *Chemical Engineers*.

Up to the present our tendency has been to keep the chemist and engineer apart; in the author's opinion this has resulted in grave loss of efficiency. For the successful development of a new process after the chemists of the research department have worked it out in the laboratory, men of Classes II and III should combine to design and test a small trial plant in order to obtain special chemical engineering data, and all three should then combine to deal with a technical unit plant, fully working out in particular the thermophysics, the thermochemistry, and the thermodynamics of the process.

Class I men are the discoverers of new compounds and reactions, and must be men of wide outlook. In addition to their chemical knowledge they must be trained in physics and physical chemistry and have some idea of engineering science, so as to be able to co-operate intelligently with Classes II and III. Men of Class II, who are required in far greater numbers, should receive a considerable amount of somewhat specialized engineering training, the outlines of which are indicated. Certain qualities of *temperament* too are essential. Men of Class III must be thoroughly trained engineers above all; the more chemistry they know the better.

To our standard schools and institutions of civil, mechanical, electrical, heating, illuminating, and aeronautical engineers we must add without delay schools and institutions of chemical engineering.

Just as the culmination of the training of chemists must be research, so must that of the engineer-chemist, but it must be research on some chemical process on a technical scale. For this purpose cheap, rough laboratories should be erected, and the work must be quantitative as regards materials, energy and cost. The work of the engineer-chemist is essentially *applied physical chemistry*.

THE FORGOTTEN FACTOR IN CHEMICAL TRAINING

Mr. W. R. Cooper presented "a plea for the forgotten factor in chemical training." However perfectly the theoretical and technical knowledge of the young chemist may be developed during his training, the all-important economic factor is wholly neglected—will any particular process pay? The idea of introducing the factor of cost is often distasteful to the teacher. Yet the results obtained regardless of cost are of no commercial value, and a commercial problem is on no lower a plane than one purely scientific, for it includes an additional factor and is more difficult of solution. In a large works the young chemist might pick up the necessary economic knowledge, but in small works this is unlikely, and in any case guidance is desirable and would prevent many unsound chemical processes being put forward.

THE TRAINING OF THE WORKS CHEMIST IN PHYSICS

Mr. Charles R. Darling described the course of physics which chemical students take at the City and Guilds Technical College, Finsbury, aggregating over the three years about a hundred and twenty lectures and two hundred hours' laboratory work. The course in sound is confined to twelve lectures; that in light includes the principles underlying and the manipulation of the instruments commonly used in chemical practice; that in heat also has special reference to technical applications, including, for example, fuels, electric furnaces, pyrometry, refrigerating machinery, and so forth.

COLLEGE TRAINING OF CHEMICAL ENGINEERS

Mr. J. W. Hinchley described "The Work of the Imperial College in the Training of Chemical Engineers." The Department of Chemical Technology was inaugurated in 1912 under the direction of Professor W. A. Bone, and the teaching of chemical engineering, for which the author is responsible, is being developed as part of a larger scheme of post-graduate study and research in chemical technology. The principal features of the course are outlined. The student has to compile a reference book from which he can at once obtain quantitative information on the subjects he has studied, such as the properties of steam, rates of evaporation from liquid surfaces, loss of heat from surfaces, and so on. He is taught the most efficient methods of calculation and how to handle technical problems too involved for exact treatment. He makes drawings of tanks, condensers, etc., and experimentally studies units of plant like filter presses, reaction towers, stills, and grinding mills. He makes original designs of simple plant for a given output of product and determines therefrom and from experimental data the cost of production of the product. The training is not intended to take the place of factory training, but to plant the seed which, with experience, will grow to wisdom. The author opposes the view that chemistry and engineering are antipodal in character.

GENERAL DISCUSSION

First a number of written contributions to the discussions were read.

Mr. G. S. Albright, in emphasizing the difference between laboratory work and works practice, pointed out that a more minute and careful study of *all the conditions* governing an experiment in the laboratory might save many mistakes outside. He was strongly impressed with the necessity to the chemist of some engineering knowledge, so that he should not be wholly at the mercy of the works engineer.

Mr. E. B. R. Prideaux thought the smaller universities might, in co-operation with local manufacturers, differentiate their courses so as to supply a sound training for a works chemist. This would involve a free application of the methods of practical physics and of physical chemistry.

Mr. H. L. Heathcote wrote that in future training for the works must be *induced* by the needs of industrial processes, with their necessary limitations, rather than *forced* by the examination syllabus and academic atmosphere. He dwelt on the difficulties in assimilating or in turning to practical account the ideas of the scientific staff that obtained in practice on account of the inevitable constitution of the works and the limitations imposed by labor and material. Schemes for education and research should bear in mind these practical limitations and the science-man must be trained to overcome them. He must be a synthesist as well as an analyst.

Dr. P. E. Spielmann wrote that only a very excep-

tional man could combine in himself the knowledge and experience of both a highly skilled chemist and a fully qualified engineer. They ought, however, to aim at a training that would enable the chemist to criticize the engineer's drawings and the engineer to grasp the chemist's requirements.

Mr. Francis H. Carr also thought it rare to meet men endowed with both chemical and engineering sensitiveness, but more men with the combined aptitudes could be discovered and developed, and one great object of college training should be the discovery of the student's potentialities. Such complex chemical manufactures as have been developed here are due to men who have been trained in or had aptitude for both chemistry and engineering. The pure chemist is often timid in attacking practical problems outside the laboratory. He advocated the establishment in colleges of a department which could be conducted something like a factory, carrying on side by side with lectures the production, say, of fine chemicals (that have hitherto been produced in Germany) on the scale of technical experiments. He submitted these proposals for serious consideration.

The subject was then thrown open for general discussion from the floor.

Sir A. McDougall Duckham supported from his personal practical experience Professor Donnan's definition of the types of chemists and engineer-chemists required by industry. He went farther, and thought chemistry should be brought into every engineering course. He insisted on the importance of bringing the practical men and the practical work of the works into the colleges, and he thought also that students should enter works before college.

Professor A. K. Huntington remarked that although a thing in a works was useless unless it could be done economically, it must be borne in mind that what does not pay to-day may very well pay under different conditions or with increased knowledge; the Haber process, which the Germans were carrying out on a huge scale, was a case in point. He suggested the use of the term "works engineer" to indicate the man trained to deal with works processes. A great difficulty at present in the training of technical students was the miserable equipment, especially in mathematics, received in the secondary school. He concluded with an appeal to the scientific man to enter the works and so, by acquiring really adequate data, ensure theory working out in practice.

Mr. A. P. M. Fleming spoke of the importance of the engineer-chemist acquiring his experience in the works, and in this connection commented on the scheme for training industrial chemists at the Massachusetts Institute of Technology that Professor Donnan had outlined, in which third-year selected men were put into, say, Portland cement works, or electrochemical or gas or alkali works, to enable them to pick up Mr. Cooper's "forgotten factor." A further part of the plan was to organize at headquarters schemes of research in connection with each of the industries. He gave some interesting details of some of the post-graduate industrial research being carried out in America, and thought the universities here should develop similar schemes. Most important of all was to attract the best brains of the country into their profession.

Dr. W. Rosenhain emphasized the importance of breadth of view in the training of the technical man, which would enable him to face problems from many points of view. The simplification in conditions which was the essence of scientific research might be a drawback when dealing with practical problems, and hence the narrow expert would fail where the man of broad

insight would succeed. But the man with scientific training is the man who is bound in the end to "make good," provided he is satisfactory material to begin with.

Dr. R. Robertson thought the teaching of engineering to chemists essential, not only for its inherent value, but because it might be used by the professor as a touchstone to determine a student's true vocation—whether for pure research or applied science. He too agreed with the necessity for the student of contact with the reality of the works.

Mr. W. Macnab spoke of the opportunity present circumstances afforded of putting into practice some of the excellent teaching they had heard propounded during the discussion. There was a sad lack of engineering chemists in the country. A hopeful sign was the breaking down of watertight compartments of knowledge.

Professor E. G. Coker said there was often difficulty in placing young engineers with more brains than money in suitable positions, and he hoped for the general adoption of plans like that of Mr. Fleming. It must not be forgotten that many good chemists were not interested in engineering, and the reverse was also true, so that any educational scheme must be permissive. Courses of engineering for chemists should be specialized; much of the ordinary engineering could not possibly be of interest to chemists. He thought some of the American courses erred on the side of overloading, and preferred the English method of taking fewer subjects and doing them very thoroughly.

Lieutenant H. C. Greenwood thought it lamentable that the process chemist should often have no share in the erection of the plant. The remedy may lie in better education, but early specialization was generally a mistake, as students do not know what branch they will take up. While engineering in the way suggested by Professor Donnan must be taught, more prominence should also be given to pure physical chemistry, which was becoming of increasing practical importance.

Mr. C. S. Garland spoke of the gain to chemists and to industry to be derived from enlarging their view by training in engineering and works experience. Sufficient inducement could be relied upon to bring the right men forward.

Dr. E. F. Armstrong, while expressing his agreement with Sir George Beilby and Professor Donnan, did not think we had a shortage of plant chemists, who had been produced in goodly numbers by the universities. Moreover, after all, what chemical industry chiefly wanted was *chemists* first and then engineering chemists to tell the engineer what was wanted. While the works knows all about costs and management, it does not know, or is too busy to keep in touch with, modern developments in chemistry. To give an example: a man specially expert in the phase rule or colloidal chemistry put into a works might revolutionize many an existing process. Such men must be produced, and to do so not only must the university enter the works, but the manufacturer must enter the university, advise it, and support it. He did not altogether believe in the deficiencies of British chemical industry. The three great achievements in industrial chemistry in the last twenty years were artificial silk, fat-hardening, and synthetic ammonia. The last did not appeal to the British (before the war) because they had plenty of ammonia, but the first was an English achievement, discovered by an Englishman, Mr. Cross, and the second was largely worked out in Great Britain.

Mr. W. Gathorne Young thought the meeting would be an epoch-marking one and that the procedure should be along the lines marked out by Professor Donnan. After the first three years of training, only those

students should take a course in chemical engineering who showed an aptitude for it. The course should include systematic visits, with demonstrations, to chemical works and vacation work at such factories. Manufacturers would co-operate if approached in the right spirit. He did not believe manufacturing processes could be taught by operating miniature plant in the laboratory. If some of the best brains have gone into other professions during the past thirty years, it is because of the miserable return that has been offered to chemists.

Mr. T. G. Elliott agreed with those speakers who had laid stress on our general want of secondary education. He thought Professor Donnan's scheme rather academic, and dwelt on the value of the university to a district when it specialized in the work of the district, such as had been done by Sheffield University, for example.

Owing to the lateness of the hour the continuation of the discussion was then deferred to another meeting.

Preparedness Census of Technical Men

At the request of the Council of National Defense, the Bureau of Mines, Department of the Interior, has undertaken a census of mining engineers, metallurgists and chemists, with the view of ascertaining the qualifications of each and the line of work in which each could be of most service to the country in time of emergency. This work is being conducted in co-operation with the American Institute of Mining Engineers and the American Chemical Society. Circular letters are being sent to about 10,000 chemists who are members of the American Chemical Society and 5000 to mining engineers and metallurgists who are members of the American Institute of Mining Engineers.

While there are a large number of mining engineers and chemists who are not members of either of these societies, an effort will be made to obtain as complete a list of these as possible. This will be done by circularizing 4500 metal-mine operators and 4000 coal-mine operators, asking that they furnish the names of mining engineers, chemists, and metallurgists in their employ. These names will be checked against the list of the two societies named, and those whose names do not appear as members of the societies will be sent a special letter asking that they furnish the bureau with a record of their experience.

The results to be obtained by this census may be briefly stated as follows: It will make available for use a classified list of chemists, mining engineers, and metallurgists. The classification will embrace twenty-seven specific groups of industrial chemists, as explosives, sanitation, foods, dyestuffs, coal, petroleum, fats and soap, sugar, etc. The mining engineers will be divided into sixteen groups of engineering work, as for example: Engineers familiar with machinery construction, building construction, dredging, drainage and pumping, underground mining, shaft sinking under compressed air, etc. The classification of metallurgists will embrace fifteen groups, as for example, alloys, chromium and manganese, copper, lead, iron and steel, zinc, etc.

By such a minute classification the bureau will be in a position to furnish on a short notice the names of specialists, as for example, alloy metallurgists, food chemists, coal or iron mining engineers, or specialists in any branch of the mineral industry, so that in case of necessity these technical men could be placed in industrial plants where they would be of most assistance to the country. Experience in foreign countries has shown that the technical men were able to render vastly

greater assistance by being placed in the factories than in the regular army.

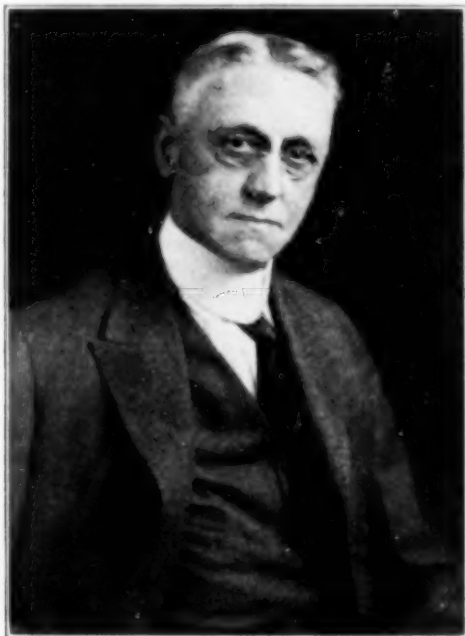
In addition to the technical classification, there will also be a classification of engineers, metallurgists and chemists according to their experience in foreign countries and languages with which they are familiar.

It is hoped that as a patriotic duty each engineer, metallurgist and chemist receiving these cards will furnish the information promptly, in order that the bureau may complete its work with the least possible delay. Complying with these requests in no way obligates the person who signs it, but has the advantage that in case of need he can be placed where his efforts will yield the best results.

David H. Browne

David H. Browne, chief metallurgist of the International Nickel Company, died on March 30, 1917, at his home in Montclair, N. J., after a short illness at the age of fifty-two.

He was born in 1864 at Hollymount, County Mayo, Ireland, and received his early education at the Londonderry Academy. At the age of sixteen he came to the United States and entered the University of Michigan, graduating in 1885. Following employment as a chemist at various metallurgical plants, Mr. Browne returned



DAVID H. BROWNE

to the University of Michigan and served as instructor in inorganic analytical chemistry in 1888 and 1889. When the Canadian Copper Company was organized he entered its service and was connected with it until it was absorbed by the International Nickel Company, the staff of which Mr. Browne joined. Most of his professional life he spent at Sudbury, Ont., but in 1914 he was transferred to the head office of the International Nickel Company in New York.

Mr. Browne's first big achievement was the development of his electrolytic process for the separation of nickel and copper in Sudbury ore, which was described in detail in our Vol. I, page 381 (see also Mr. Browne's articles on certain technical phases of this work in our Vol. I, pages 273 and 348). This process was in successful commercial operation for several years, but when the Canadian Copper Company was absorbed by the Inter-

national Nickel Company the process was abandoned in favor of the cheaper Oxford process owned by the latter company.

The second big achievement of Mr. Browne was the successful reduction to practice of powdered-coal firing of reverberatory smelting furnaces. This he was the first to do successfully on a large scale at Sudbury, and he freely gave full information of the success obtained and the means employed to others to follow suit.

In 1916 the honorary degree of Doctor of Laws was conferred on him by Queens University.

Mr. Browne is survived by his widow and three sons.

An appreciation of David H. Browne as a man will be found in an editorial on page 415 of this issue.

Annual Meeting of American Chemical Society at Kansas City

(By Telegraph)

The annual spring meeting of the American Chemical Society was opened on Tuesday evening, April 10, at the Hotel Muehlebach, Kansas City, Mo. About 335 members were registered at the opening of the meeting.

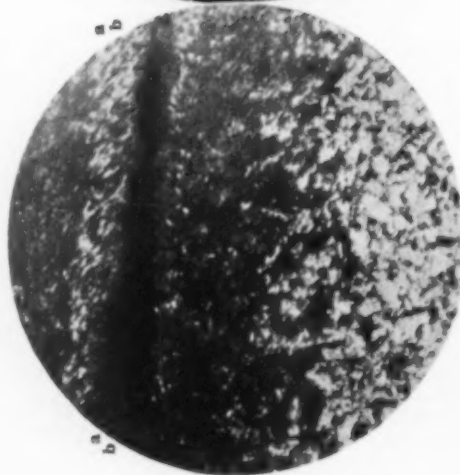
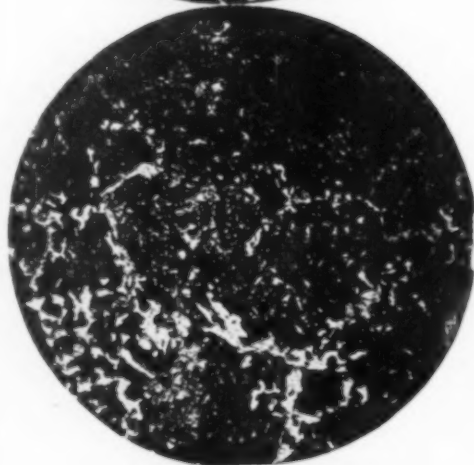
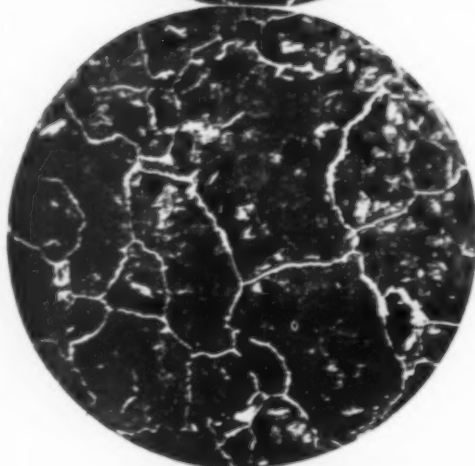
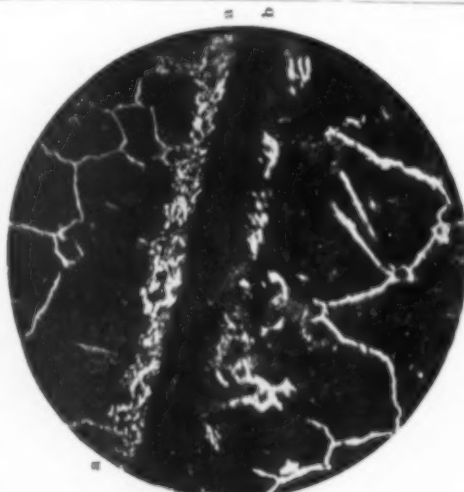
A dinner was tendered to the Council at 6.15 p.m. at the University Club, by the Kansas City Section. After the dinner the Council held a meeting in the assembly room of the Muehlebach. The report of the Committee on Co-operation of Universities and Industries and of the Committee on Analysis of Chemical Reagents were taken up. A resolution was adopted that local sections of the society shall have no authority to publish or issue resolutions representing official action of the society on national questions. It was decided to hold the next meeting in Boston during the week of Sept. 10, 1917. A committee was appointed to act on behalf of the society in questions pertaining to the present national crisis.

On Wednesday morning a general meeting was held in the hotel. The meeting was opened by Prof. W. A. WHITAKER of the University of Kansas. Mayor EDWARDS was scheduled to speak, but was unable to be present. He sent a representative, who welcomed the society to the City. Dr. FRANK STRONG, chancellor of the University of Kansas, delivered the opening address on "What War Means to College Men." Dr. JULIUS STIEGLITZ, president of the society, responded, and said that the society could aid greatly in the crisis by seeing that things are conducted scientifically and efficiently. Chemical work is essential for the welfare of the country, especially research. He said that by a resolution of the council the services of the society would be offered to the Government. In order to conserve our platinum resources he urged women not to use it in jewelry, and said it should not be used in photography.

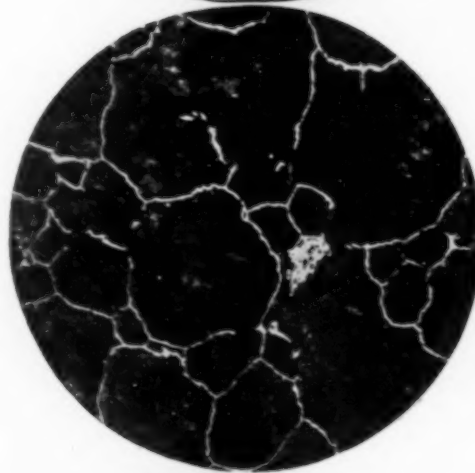
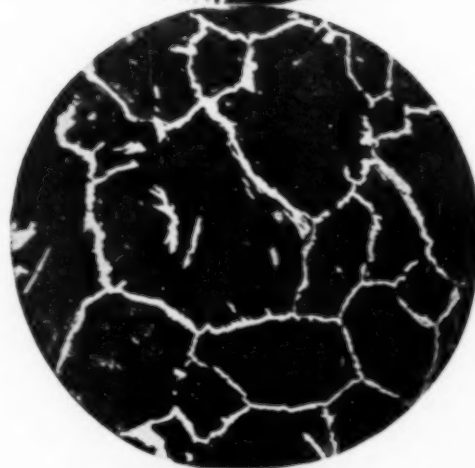
ARTHUR J. BOYNTON presented a paper on "The Economic Resources of the Kansas City Zone." He said it was the natural center of the Southwest. He spoke of the railroads, bank clearance, agriculture, oil and gas, packing houses, soap and glycerin, flour and grist mills, cement, glass, brick, and metallurgical industries.

The Wednesday afternoon session was devoted to papers on Petroleum and Gas. H. P. CADY acted as chairman. WALTER F. RITTMAN's paper on "Synthetic Gasoline in 1918" was read by Gustav Egloff. He said we would produce one billion gallons of synthetic gasoline in 1918. Dr. Egloff, in an addendum to the paper, said we would save \$25,000,000 yearly in benzene, toluene and xylene if the gas standard was changed from an illuminating to a heat basis.

A full account of the whole meeting and of the technical sessions will be published in our next issue.

A₁ (775 Deg. C.)A₂ (825 Deg. C.)A₃ (875 Deg. C.)A₄ (960 Deg. C.)

MICROPHOTOGRAPHS OF STEELS "A" AFTER CEMENTATION

A₅ (905 Deg. C.)A₆ (1010 Deg. C.)A₇ (1100 Deg. C.)A'₅ (800-950 Deg. C.)

MICROPHOTOGRAPHS OF STEELS "A" AFTER CEMENTATION

Exfoliation and Carbon Concentration in the Case-Hardening of Steel*

By Edwin P. Stenger

Instructor in Metallurgy, University of Cincinnati

The demands being made on the cementation process by the different industries, especially the automobile and machine tool industries, can only be met by a better and a more detailed study of the principles and phenomena underlying this process. That great effort is being made to fill these demands is shown by the fact that so much attention and time is being given to research in this field of metallurgy by the most noted chemists and metallurgists.

Cementation of steel is defined as any process by which the carbon content of the whole or of a superficial layer of a steel object is increased without subjecting it to fusion. The object of the process is attained by heating iron or steel in contact with some carbonaceous material to a high temperature. The iron, in order to take up carbon from the carburizing material, must be heated to a sufficiently high temperature to be changed to the gamma condition.

If cementation is conducted so that only the carbon content of a superficial layer is increased, while the core is left unchanged, the process is called "case-hardening." If the treatment is continued for a longer time and at a higher temperature the whole of the mass becomes cemented. This method is termed "total cementation."

Although the best grades of crucible steel are still manufactured from iron that has been totally cemented, this method of making steel, originally the only one, has for economic reasons been almost entirely superseded by the Bessemer and open-hearth processes. Because other processes for steel making have been substituted, "total cementation" has become less important. On the other hand, superficial carburization is becoming more and more important, due to the recent advances in the technology of mechanical construction.

The most serious problem met with in the superficial cementation and hardening of machine parts is the phenomenon of exfoliation. This phenomenon is well known to all connected with the technique of case-hardening and to those who have occasion to examine the fracture of case-hardened pieces, after their failure in service. It very often happens that the cemented zones of a case-hardened object, especially if subjected to alternating shocks, as most cemented material is, splits or exfoliates from the core. This phenomenon has received the attention of Dr. Giolitti in his epoch-making work on cementation and to him is due credit for what little is known of this subject. He has investigated the distribution of carbon in the cemented zones obtained by carburizing with several of the hydrocarbon gases. This distribution of carbon in the cemented zone of case-hardened material has, as will be seen later, an important bearing on exfoliation.

It is evident that exfoliation is caused by some internal strain being produced during case-hardening. How these excessive strains could be produced by the case-hardening process has not been fully investigated.

During January and February, 1915, E. H. Schulz published in the "Zeitschrift des Vereins deutscher Ingenieure" a very important article on the changes in volume which steel undergoes during hardening. Several steels of different composition were heated by him to various temperatures and then quenched in oil and water. By finding the specific gravity before and after hardening, the increase in volume was determined. His results showed that the higher-carbon steels gave

greater increases in volume on hardening than did the low-carbon steels. Only a small increase in volume was obtained by quenching a steel whose carbon content was equal to .16 per cent. It should be noted that this is about the carbon content of most steel before it is subjected to superficial cementation.

With these fundamental facts as a basis, the writer undertook the present investigation. He thought that the greater increases in volume observed by Schulz in the hardening of the higher-carbon steels might be responsible for the phenomenon of exfoliation. It can be perceived that strains are produced in the case-hardening process if the higher-carbon case tends to increase in volume, while the low-carbon core tends to remain unchanged in size. The cemented zone will tend to expand from the unaltered core, thereby producing stress between the two which, if too great, will eventually result in rupture. In order to determine how great these stresses are, the following experiments were performed.

Carbon Concentration

The three types of steel most generally used for industrial cementation are ordinary low-carbon steel, nickel steel, and chrome steel. Materials of these types having the following composition were obtained:

Steel	C	Mn	Si	Ni	Cr	P	S
A.....	0.15	0.89	0.04	.....	.....	<0.05	<0.05
B.....	0.14	0.54	0.02	.....	.....	<0.05	<0.05
Ni.....	0.19	0.70	0.12	3.37	.....	<0.05	<0.05
Cr.....	0.58	0.61	0.13	0.75	1.40	<0.05	<0.05

Steel B had been refined in an electric furnace. This steel was very kindly donated by the John A. Crowley Company of New York and was rolled by the Andrews Steel Company of Newport, Ky. Specimens of this steel were obtained for the experiments by shearing a No. 16 gage sheet of it into 1¼-in. squares. Specimens of the other three steels were obtained by cutting thin disks from a round bar. These disks were 1½ in. in diameter and varied in thickness from 1/32 to 1/16 of an inch. A serial number was stamped on each piece in order that a record of its treatment might be kept.

These specimens were cemented in steel containers with a commercial carbonizing material called "Achilles." Each charge was made up of fresh carbonizing material in order that the composition would be the same in all cases.

The containers were made of two pipe sleeves joined together by a nipple having a diameter of 2½ in. Both ends were closed with iron plugs. In one of these plugs a hole was drilled to permit the insertion of a thermo-couple, and also to serve to keep the gases under constant pressure, that is, atmospheric pressure.

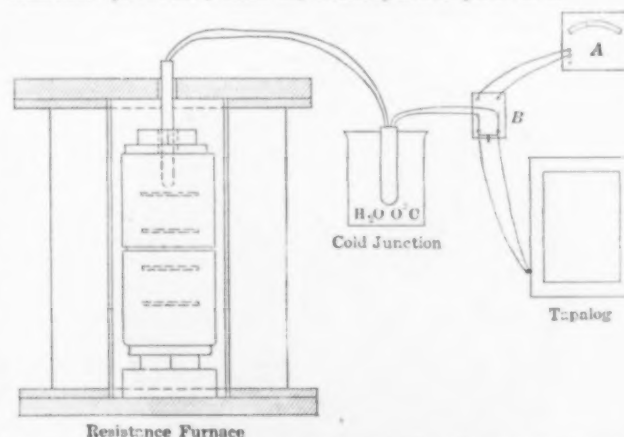
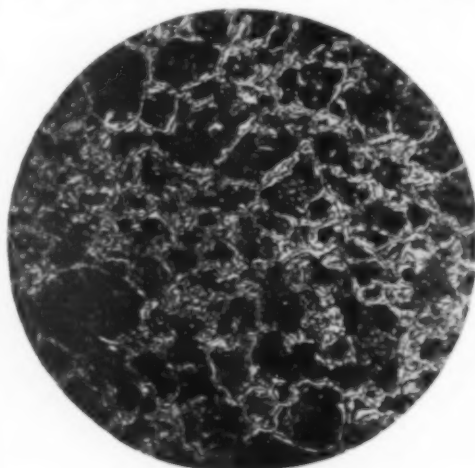
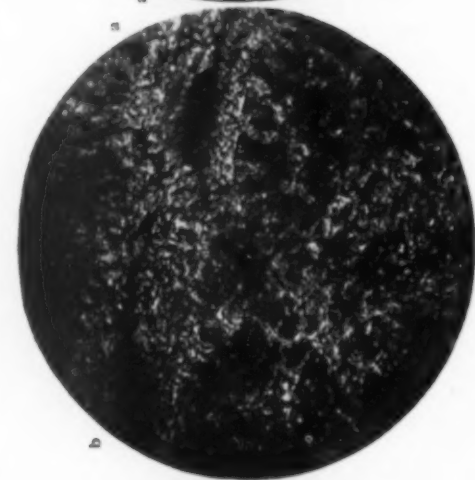
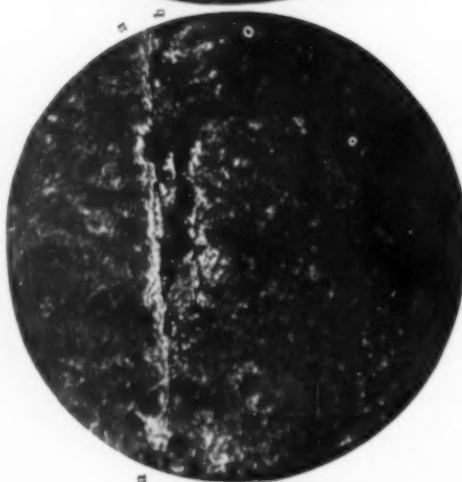
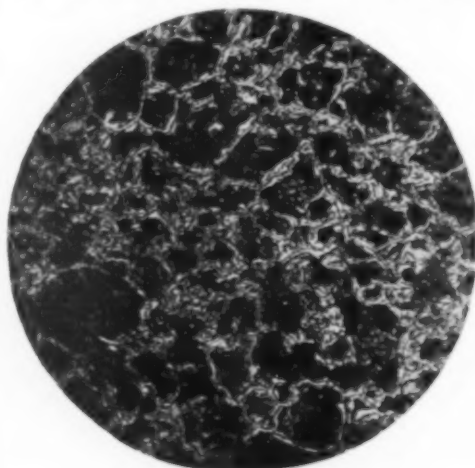
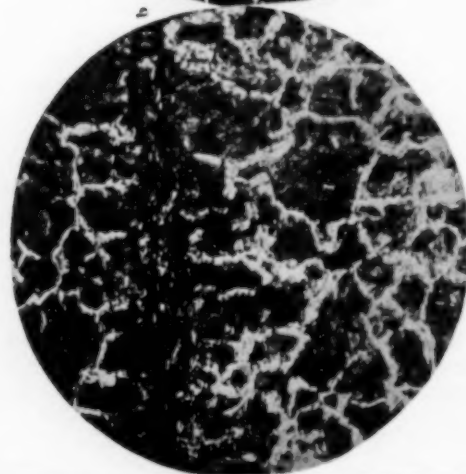
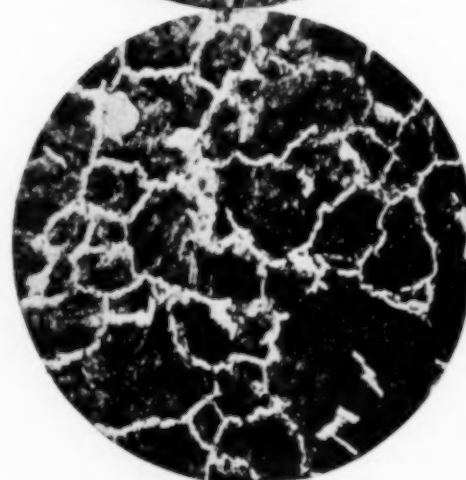
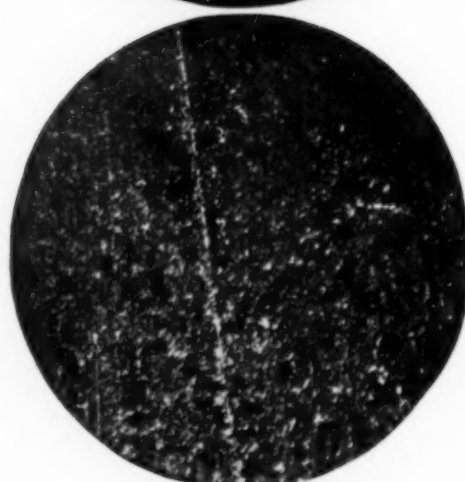
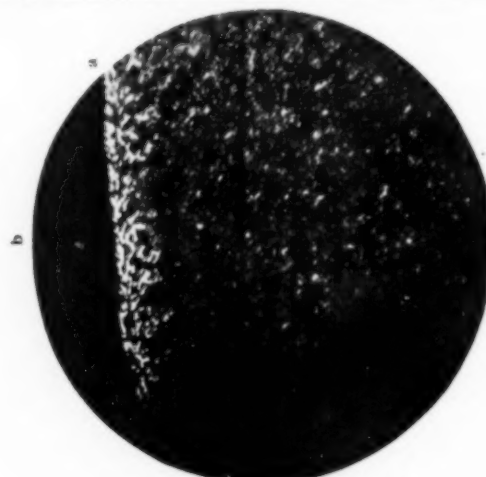


FIG. 1—ARRANGEMENT OF APPARATUS FOR CEMENTATION EXPERIMENTS

*Hochstetter Prize Thesis, University of Cincinnati, 1916.

B₁ (740 Deg. C.)B₂ (800 Deg. C.)B₃ (850 Deg. C.)B₄ (910 Deg. C.)B₅ (945 Deg. C.)B₆ (1050 Deg. C.)N₁ (790 Deg. C.)N₂ (845 Deg. C.)

MICROPHOTOGRAPHS OF STEELS "B" AFTER CEMENTATION

MICROPHOTOGRAPHS OF STEELS "B" AND NICKEL STEELS AFTER CEMENTATION

The above description of the containers and the method of packing will be more clear if reference is made to Fig. 1, which shows the arrangement of the apparatus used for the cementation experiments.

The containers and their contents were heated in a wire-wound resistance furnace, to various temperatures. In these experiments it was endeavored to obtain the maximum concentration of carbon, corresponding to the saturation of iron, at a constant temperature. Therefore, the temperature was kept constant and the time of cementation was extended over as long a period of time as possible. In some instances, especially for the lower temperatures, the electric current could not be had long enough to cause the total cementation of the thin disks. The current was supplied by the University power plant which was in operation from only eight to fifteen hours each day.

One of the records of the temperature which were made by a tapalog recording pyrometer is reproduced

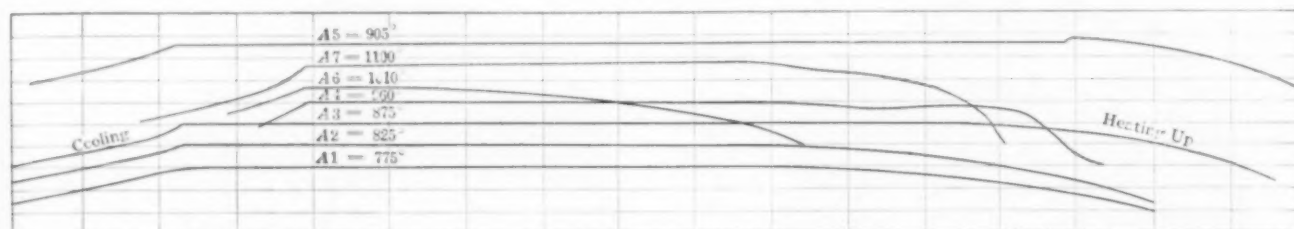


FIG. 2—TIME-TEMPERATURE CURVES FOR "A" STEEL

in Fig. 2. This instrument was not calibrated for the platinum-rhodium couple which was used, therefore the records serve only to show how nearly constant the temperature was kept and how long each charge was subjected to cementation. The real value of the temperature was obtained from observations made on the unipivot instrument A (Fig. 1) by throwing the double-pole double-throw switch B. The temperature record in Fig. 3 will be referred to below.

After cementation, microsections of the disks were made and examined in order to determine the structure

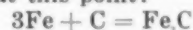
These microphotographs show a non-uniform distribution of carbon in the specimens A₁, A₂ and B₁. Although the thinnest sections were used for the lower temperatures, the electric current could not be had for a sufficient number of consecutive hours to establish complete equilibrium at these low temperatures.

The photographs also show another very interesting structure. Note the zones *a-a* and *b-b*. The zones *b-b* are not structural features, but only represent the space between the surface of the two adjoining disks. In some cases these openings are not discernible because the two surfaces are in such close contact. However, the zones *a-a* are segregations of cementite (Fe₃C) and show the structure at the extreme edge of the section. This structure could not have been shown if the edges had been rounded by polishing.

It will be observed that these segregations of cementite or supersaturated zones occurred in some of the disks of all four types of steel used. This phenomenon

was not confined to either high or low temperatures nor to those disks which were saturated with carbon.

At first, one would conclude that since iron and carbon have been in contact at the surface and since iron carbide has resulted, that the following reaction must have taken place at this point:



The zones *a-a* would then represent the regions in which this iron-carbide or cementite is formed according to the above reaction. Cementation could then proceed by the diffusion of this cementite into the core, due to the

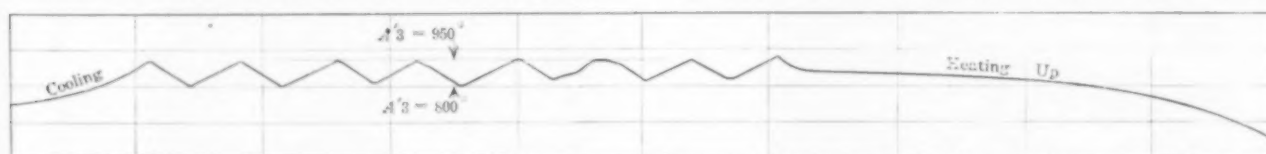


FIG. 3—TIME-TEMPERATURE CURVES FOR A'

and to see if the carbon was uniformly distributed throughout the entire section. The microsections were made by clamping together the four disks of each charge by means of a small bolt and then grinding and polishing a surface parallel to the axis of the bolt as shown in Fig. 4. If each disk had been polished separately, the edges would have been rounded, in which case the whole of the field could not have been brought into focus. For this reason they were clamped together, thus protecting six edges while only two were rounded.

To show the structure and the points of interest brought out in the microscopical examination microphotographs (x 125 diameter) were made of the micro-sections and are reproduced on pages 424 and 426.

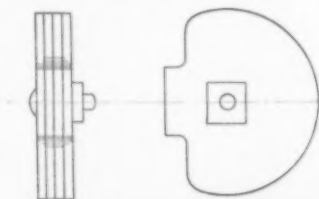
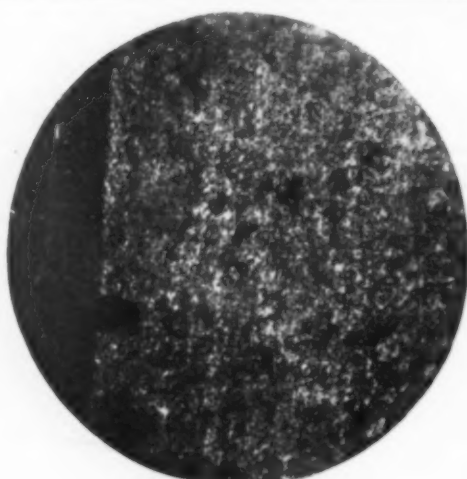


FIG. 4—METHOD OF MAKING MICROSECTIONS

difference in concentration. Although cementation may in part be due to the diffusion of the cementite from the surface to the core, this is not the preponderating agent of carburization, as will be shown.

If formed in the manner described above these segregations of cementite would be found in all cases where the rate of formation of the carbide of iron would exceed the rate of diffusion. We would, therefore, expect to find these supersaturated zones in all of the micro-sections, since the rate of diffusion is zero when complete saturation is reached. Since these zones are found in only a few of the specimens, it is evident that they could not be formed in the above manner.

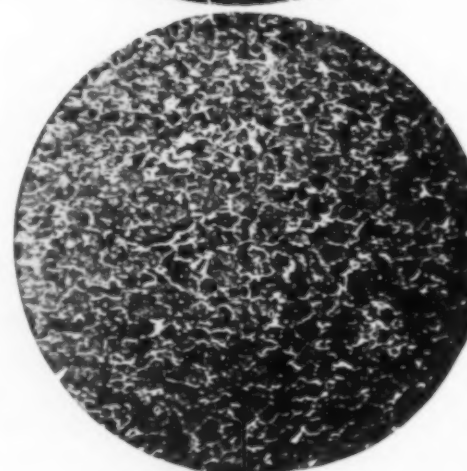
Giolitti found that no segregations of cementite appear when the temperature is kept rigorously constant, but that these supersaturated zones form only when there are oscillations in the temperature. In the microscopical examination it was found that supersaturated zones had formed in several of the specimens that had, according to the time-temperature curves, been subjected to the most constant and uniform temperature.



Ni (910 Deg. C.)

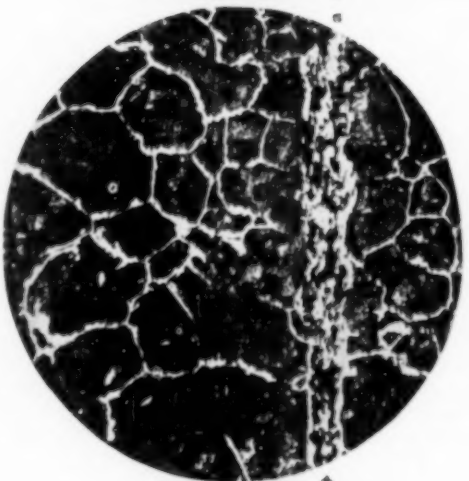
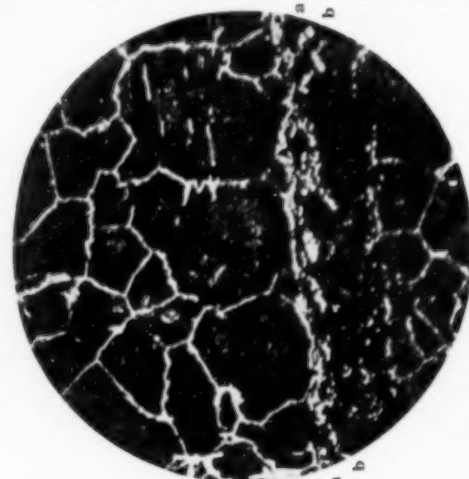


Ni (1010 Deg. C.)



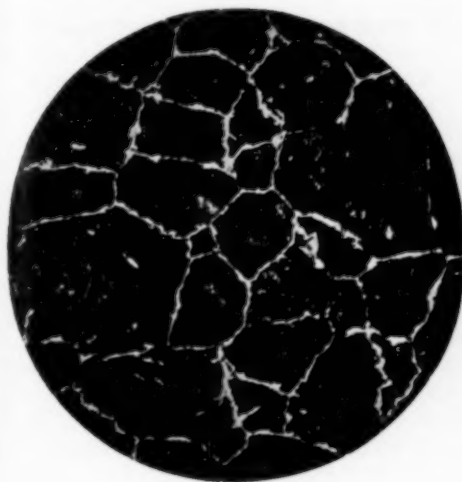
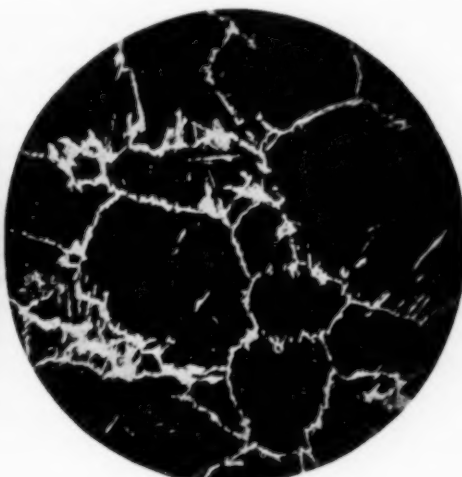
Ni (1110 Deg. C.)

b

Cr₁ (730 Deg. C.)Cr₂ (800 Deg. C.)Cr₃ (860 Deg. C.)Cr₄ (890 Deg. C.)Cr₅ (940 Deg. C.)

MICROPHOTOGRAPHS OF NICKEL AND CHROME STEELS AFTER CEMENTATION

MICROPHOTOGRAPHS OF CHROME STEELS AFTER CEMENTATION

CR₁ (995 DEG. C.)CR₂ (1050 DEG. C.)

In order, therefore, to determine whether oscillations of temperature had any effect on the formation of these carbide segregations, the disks Nos. 20, 10, 11, and 16 of charge A₁ were again packed and subjected to cementation. This time the temperature instead of being kept constant was made to oscillate as is shown in Fig. 3. From the microphotographs A', made after this treatment, we can conclude that Giolitti's hypothesis was correct. A detailed explanation of the mechanism of the formation of these abnormal concentrations is given by him.*

It was observed in these experiments that the disks which were placed nearest to the top of the containers most frequently contained the segregations of cementite. In some cases the top disks contained considerable of the segregation while the other three were entirely free of it. The upper disk was not insulated as thoroughly as the other three were because it was covered with a much thinner layer of carbonizing material; therefore, its temperature oscillated more readily. This fact makes it doubtful whether much benefit will be derived from the work that is being done in search of a carbonizing material which is more permeable by heat.

Abnormal concentrations of cementite are formed in industrial cementation, especially if the furnaces used are fired intermittently as is the hand-fired coal furnace which gives a temperature curve somewhat similar to Fig. 3. These zones of cementite if formed in case-hardened parts will, when subjected to shock, flake from the surface in the form of thin plates. This flaking off of the supersaturated zones should not be confused with the phenomenon of exfoliation in which the entire case splits off. Although a rough surface may result from this cause, the problem is not serious because the zones are exceedingly thin. The cementite zone as it is shown in photograph A', (the last microphotograph in the A series) is about 1/4 in. wide, which means that its actual thickness is about two-thousandths (0.002") of an inch. In practice these zones seldom exceed this thickness.

The segregations of cementite were removed from the disks by carefully grinding a thin layer of metal from the surface of each specimen. After this was done, drillings were taken from the disks of each charge and a determination of the carbon was made by direct combustion. These carbon determinations were made by Prof. E. E. Thum, for which assistance the author takes this opportunity to express sincere thanks. Likewise hearty thanks are due to Prof. James Aston under whose direction this work was started and to Prof. A.

L. Jenkins for his help on the mathematics connected with this investigation.

The value of the carbon thus obtained represents the maximum concentration of carbon corresponding to the saturation of iron at a constant temperature. Other investigators have attempted to determine these saturation points but their results, as they themselves have pointed out, are entirely too high because their analysis included the cementite segregations. They were unable to remove these segregations because fine wires were used for specimens. For this reason disks were used

for the specimens in the present experiments, which permitted the supersaturated zones to be ground off.

By plotting carbon against temperature, the temperature-concentration curves shown in Figs. 5 and 6 were obtained. If carbon were transmitted from the surface to the core by the diffusion of cementite only, these temperature-concentration curves would coincide with the

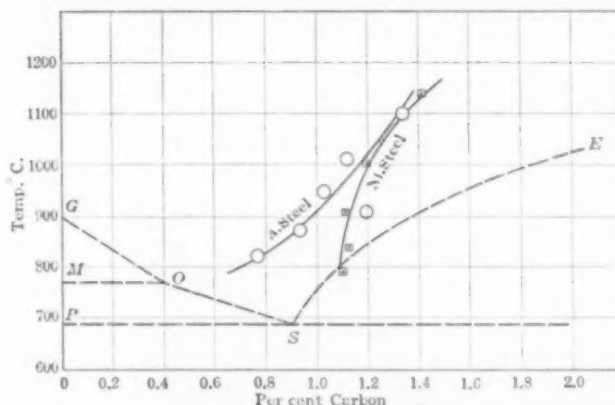


FIG. 5—TEMPERATURE CONCENTRATION CURVES

branch SE of the equilibrium curve of the iron-carbon system. These curves are greatly displaced from SE and are of a different shape. The fact that these curves do not coincide with SE confirms the recent theory that the carbon is transmitted by means of gases, rather than by diffusion of cementite, into the pores of the iron and on decomposition set up an equilibrium between carbon, carbon monoxide, carbon dioxide, and the solution of iron carbide in iron.

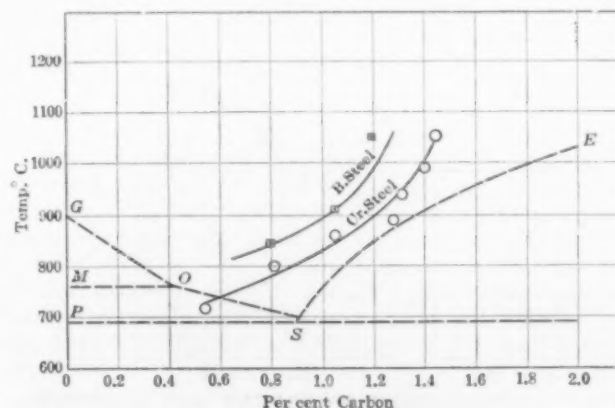


FIG. 6—TEMPERATURE CONCENTRATION CURVES

*See the "Cementation of Iron and Steel," by F. Giolitti.

The temperature-concentration curves for *A* and *B* steel almost coincide, showing that small variations in the impurities always found in steel in the usual small amounts do not have a marked effect on the saturation point. On the other hand, the saturation curves are considerably lowered by high percentages of chromium and nickel. From the generally accepted theory that gamma iron is necessary to cementation, these curves should be tangent to the gamma iron transformation line on the iron-carbon diagram. The presence of nickel in steel has the known effect of materially displacing this transformation, which may account for the changed shape of the concentration curves.

The data for the preceding experiments are shown in tabular form in Table I.

TABLE I

Charge	Serial No.	Time, Hrs.	Temp., Deg. C.	Per Cent Carbon	Microscopic Examination	
					Interior Structure	Cementite Segregation
A ₁	14-19-22-31-34	7	775	...	Non-uniform	Little
A ₂	12-21-24-25	7	825	.77	Non-uniform	None
A ₃	20-10-11-16	10	875	.94	Uniform	Little
A ₄	1-3-4-5	6	960	1.03	Uniform	Considerable
A ₅	26-30-41-46	13	905	1.20	Uniform	None
A ₆	18-17-32-33	13½	1010	1.12	Uniform	None
A ₇	8-15-23-27	6	1100	1.36	Uniform	None
A ₈	20-10-11-16	...	800-950	...	Uniform	Excessive
B ₁	104-15-30-33	11	740	...	Non-uniform	Some
B ₂	102-08-17-29	10	800	.85	Rather uniform	Little
B ₃	105-24-25-32	11	850	.78	Non-uniform	Little
BH ₁	119-10-23-31	9	910	1.05	Uniform	Little
B ₄	111-16-21-26	11	945	1.14	Uniform	None
B ₅	117-09-22-27	8	1050	1.20	Uniform	None
Ni ₁	202-17-21-19	9	790	1.10	Uniform	None
Ni ₂	223-25-11-10	9	845	1.13	Uniform	Considerable
Ni ₃	207-08-13-14	9	910	1.10	Uniform	Very little
Ni ₄	203-04-05-06	11	1010	1.19	Uniform	None
Ni ₅	241-01-20-16	5	1140	1.42	Uniform	None
Cr ₁	319-16-31-32	12	730	.54	Uniform	Considerable
Cr ₂	311-17-20-25	11	800	.81	Uniform	No. 332 only
Cr ₃	300-10-24-35	13	800	1.05	Uniform	Very little
Cr ₄	305-15-23-30	12	890	1.28	Uniform	Little
Cr ₅	307-12-21-32	10	940	1.31	Uniform	None
Cr ₆	302-04-14-34	10	995	1.40	Uniform	Very little
Cr ₇	301-03-13	7	1050	1.45	Uniform	None

Exfoliation

Coming back to the problem of exfoliation, it was now endeavored to determine the increase in volume caused by the hardening of steel. Although, as has already been mentioned, Schultz made similar determinations his results have not been applied to practical problems and processes.

The case and the core of cemented parts differ in composition, so far as is known, only in the amount of carbon that they contain. This being the case the stresses due to volume changes in cemented parts must depend on this one element alone. The specimens of steel used by Schultz in his experiments were picked at random and contained all the elements usually found in steel in varying amounts. Then too, most of the steel

used by him had a much lower carbon content than that which cemented zones generally have.

On the other hand, the specimens prepared from the same material, as the disks in the above experiment were, differ only in carbon and the results obtained by determining the changes in volume on hardening these disks are therefore more applicable to cementation problems. Consequently, the disks, after the cementite segregations had been removed, were heated to 850 deg. C. and then rapidly cooled from that temperature by quenching in water.

The arrangement of the apparatus for this operation is shown in Fig. 7, which is self-explanatory. Two specimens of each steel which had not been cemented were also hardened in the above manner.

After hardening, the specific gravity of each of the specimens was determined and the results are shown in Table II, and in the form of curves in Fig. 8.

A most important and astonishing fact was revealed by the determination of the specific gravities of the nickel steel. From the data it can be seen that the specific gravity of the nickel steel after it is cemented and hardened is actually greater than that of the same material which is hardened but not cemented. Since

TABLE II
A. STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Gravity*	Average Specific Gravity	Charge	Per Cent Carbon	I	St
A ₁	25.0875	21.8978	7.866	7.868	A	.15	1.000	0
A ₂	26.5800	14.4752	7.869					
12	6.7762	5.0071	7.796	7.794	A ₁	.78	1.0065	88,000
25	9.7513	8.5001	7.793					
21	9.5418	8.3176	7.794					
1	14.8752	12.9626	7.777	7.777	A ₁	1.03	1.0078	105,000
4	13.3533	11.6364	7.777					
30	8.5790	7.4787	7.797	7.793	A ₁	1.20	1.0087	117,700
46	9.7356	8.4868	7.796					
41	12.0284	10.4831	7.784					
17	13.5431	11.8015	7.776	7.774	A ₁	1.16	1.0085	114,000
32	11.5563	10.0709	7.779					
33	14.2876	12.4480	7.766					
23	14.1166	12.3016	7.777	7.777	A ₁	1.36	1.0094	126,500
15	9.6962	8.4494	7.776					
8	13.6782	11.9194	7.777					

*Determinations made at 23 degrees C.

this is true, the core of this steel tends to expand more than the cemented zone, which is just the reverse of what happens when other steels are case-hardened. Therefore, tension and not compression is produced in the cemented zones of case-hardened nickel-steel parts. If this tension becomes too great, rupture will occur but

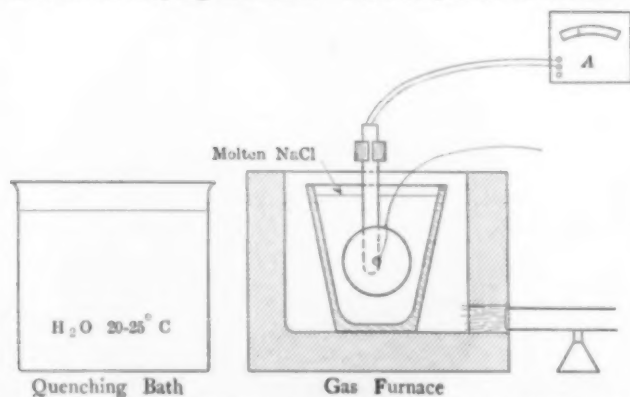


FIG. 7—ARRANGEMENT OF HEATING AND QUENCHING APPARATUS

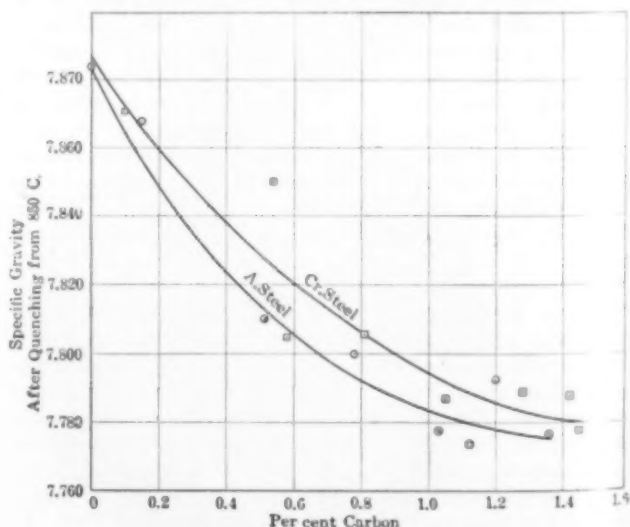


FIG. 8—DENSITY-CARBON CURVES

TABLE II (Continued)

B. STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Grav-ity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
B.....	9.4855	8.2836	7.892	7.896	B	.14	1	0
B.....	9.4358	8.2402	7.899					
117.....	8.3125	7.2489	7.816	7.814	B ₂	.84	Not calculated because the density was so affected by rolling that the specific gravity of the average carbon content could not be taken from curve	
129.....	9.1918	8.0160	7.817					
103.....	8.3248	7.2588	7.810					
132.....	8.2868	7.2270	7.818	7.815	B ₂	.78		
124.....	9.0522	7.8761	7.813					
105.....	9.0530	7.8946	7.815					
110.....	7.9871	6.9635	7.801	7.799	B ₁	1.05		
123.....	9.4678	8.2541	7.800					
131.....	8.4200	7.3400	7.797					
126.....	7.2735	6.3423	7.810	7.806	B ₃	1.14		
121.....	8.4503	7.3679	7.807					
116.....	8.3147	7.2490	7.801					
122.....	8.2818	7.0924	7.804	7.808	B ₄	1.2		
127.....	5.9100	5.1541	7.818					
107.....	7.3433	6.4023	7.804					

NICKEL STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Grav-ity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
Ni.....	18.0702	15.7742	7.870	7.868	Ni	.19	1	0
Ni.....	17.0084	14.8460	7.865					
221.....	3.8720	3.2972	7.944	7.931	Ni 1	1.11	1	Negative
217.....	3.7408	3.2694	7.938					
222.....	11.4110	9.9682	7.909					
211.....	13.1711	11.5018	7.898	7.911	Ni 2	1.13	1	Negative
210.....	11.2938	9.8653	7.905					
205.....	8.3384	7.2830	7.901					
207.....	13.6503	11.9201	7.889	7.898	Ni 3	1.10	1	Negative
208.....	8.3384	7.2830	7.900					
214.....	8.9293	7.8000	7.904					
202.....	13.5907	11.8667	7.883	7.891	Ni 4	1.19	1	Negative
205.....	17.0350	14.8779	7.892					
204.....	16.8756	14.7389	7.897					
241.....	10.9046	9.5244	7.901	7.890	Ni 5	1.42	1	Negative
230.....	18.4453	15.1033	7.876					
201.....	15.4645	13.4095	7.869					

CHROME STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Grav-ity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
Cr.....	16.8462	14.7089	7.870	7.870	Cr	.15	1	0
Cr.....	24.7193	21.5789	7.871					
319.....	4.0065	3.4966	7.857	7.850	Cr 1	.54	1.0034	41,400
326.....	3.3973	2.9656	7.869					
316.....	7.1102	6.2013	7.823					
325.....	6.6514	5.7905	7.808	7.806	Cr 2	.81	1.0065	89,700
317.....	4.9531	4.3196	7.818					
320.....	6.2789	5.4734	7.795					
310.....	11.3962	8.9308	7.777	7.787	Cr 3	1.05	1.0070	95,000
324.....	56.4725	5.6432	7.804					
300.....	11.1936	10.6266	7.781					
315.....	9.9382	8.6620	7.787	7.789	Cr 4	1.28	1.0091	122,800
321.....	6.0519	5.2769	7.802					
303.....	9.9020	8.6291	7.779					
333.....	7.5876	6.6147	7.799	7.781	Cr 5	1.31	1.0092	124,800
312.....	14.3212	12.4794	7.776					
321.....	9.1627	7.9834	7.770					
314.....	8.8145	7.6822	7.784	7.782	Cr 6	1.40	1.0096	128,900
302.....	14.7921	12.8890	7.773					
304.....	9.6173	8.3828	7.790					
301.....	15.6052	13.5977	7.773	7.775	Cr 7	1.45	1.0098	131,600
313.....	14.2587	12.4254	7.777					
303.....	12.6872	11.0576	7.778					

*Determinations made at 23 degrees C.

the resulting crack will be normal and not parallel to the surface as is the case in exfoliation.

These conclusions are confirmed by observations made by those engaged in the practice of cementation. During the writer's own experience he has never observed exfoliation to take place in case-hardened, nickel-steel

parts; the only trouble encountered in the cementation of this steel having been the cracks normal to the surface, which are occasionally produced.

Since the cylinder is the most common form used in case-hardened parts, an equation for the value of the stresses which tend to produce exfoliation in such a cemented form was derived by the application of the principles of mechanics. In this analysis of the stresses produced in a cylinder during case-hardening, the core was assumed to remain fixed in size. The cemented zone was considered to be a thin ring tending to expand away from the core but prevented from so doing by the internal stresses.

The following notations were used in the subsequent analysis:

D = mean diameter of the case before hardening in inches.

D' = mean diameter of the case after hardening in inches.

I = coefficient of total linear expansion due to hardening (not coefficient of thermal expansion).

S_h = unit hoop stress in pounds per square inch.

T = total hoop stress in pounds.

p = unit radial stress in pounds per square inch.

b = breadth of ring or length of cylinder

t = thickness of case in inches.

S_r = radial stress in pounds.

φ = Poisson's ratio of lateral contraction.

E = Young's modulus of elasticity for steel.

Fig. 9 shows the manner and direction in which the different forces act.

$$D' = DI.$$

The difference in the mean circumferential length before and after hardening equals:

$$(D' - D)$$

Unit elongation equals:

$$\frac{(D' - D)}{D} = \frac{D' - D}{D} \quad (1)$$

From Hook's Law, E equals unit stress divided by unit elongation. Therefore, since E remains about the same for all steel regardless of treatment and composition:

$$E = \frac{S_h D}{D' - D} \quad (2)$$

$$S_h = \frac{E (D' - D)}{D}$$

$$T = bt S_h = \frac{bt (D' - D) E}{D} \quad (3)$$

$$pDb = 2T \quad (4)$$

$$p = \frac{2T}{Db} = \frac{2Et (I - 1)}{D}$$

$$S_h = \frac{pD}{2t} = E (I - 1) \quad (5)$$

$$S_r = p + \varphi S_h \quad (6)$$

$$S_r = \frac{2Et (I - 1)}{D} + \frac{1}{4} (I - 1) E \quad (7)$$

Equation (7) gives the value of the stresses produced in hardening a cemented cylinder. The stresses occurring in other case-hardened parts, such as gears, pinions, cams, and the like, can be analyzed in a similar manner. From this equation it will be seen that the stresses not only depend on the volume changes due to differences in the composition of the core and the case but also on the thickness of the case and the diameter of the piece to be cemented.

The diameter D for a given machine part is fixed so that the only two factors by which the stresses can be

governed are the thickness of the case (t) and the coefficient of linear expansion (I) due to hardening.

The thickness of the case depends upon the time, temperature, pressure, etc., at which cementation takes place and can be controlled by governing these factors. A predetermined thickness of case can be obtained by consulting time-penetration curves that can be prepared for the various carbonizing materials.

As far as is known, besides the present investigation no work has as yet been done on the other factor

curves of the carburizing material that is used. Giolitti has determined these curves for some of the gaseous carbonizers but not much data is as yet available for the solid cements. For simplicity it was assumed that the carbon distribution curve for the cemented zone of the cylinder was a straight line, from which it follows that the average carbon content of this zone is equal to one-half the sum of the carbon contents of the surface layer and of the core.

The specific gravity of the average carbon content is found from the curves in Fig. 8. I is obtained by dividing the specific gravity of the core by the specific gravity which corresponds to the average of the cemented zone. By substituting this value of I together with the diameter D and the thickness t in equation (7) we find S_r . This method of computation is made more clear by the following example, in which the stress for a cylinder of A

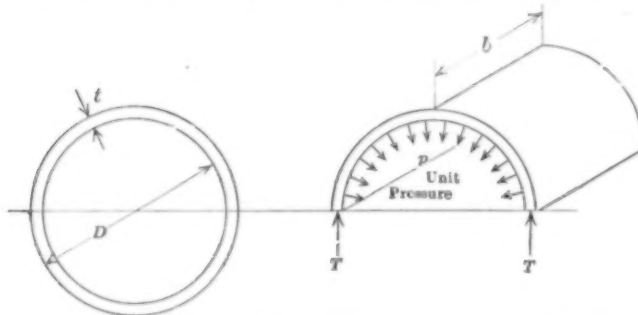


FIG. 9—FORCES ACTING IN CYLINDER DURING CASE HARDENING

of control I , the coefficient of total linear expansion due to hardening.

From the specific gravities determined above, it is seen that I depends on the amount of carbon that is present in the core and case. Equation (7) shows that small variations in I have a very marked effect on the stresses. To show how the stresses depend on the volume changes or indirectly on the carbon content the above data were used to calculate the stresses S_r produced by hardening a cemented cylinder 1 inch in diameter and having a case one-tenth of an inch in thickness.

The carbon is not uniformly distributed in the cemented zone but diminishes from the surface to the core. The mean average value of the carbon in the cemented zone must therefore be used in calculating the stresses and it is obtained from the carbon distribution

steel having a carbon concentration of 0.65 per cent at the surface was found.

Average concentration of carbon = $\frac{1}{2} (0.65 + 0.15) = 0.4$ per cent.

Specific gravity from curve = 7.824.

$$I = \frac{7868}{7824} = 1.00562$$

$$t = 0.1 \text{ in.}$$

$$D = 1 \text{ in.}$$

$$S_r = \frac{2Et(I-1)}{B} + \frac{1}{4}(I-1)E = 75,900 \text{ lb. per sq. in.}$$

By similar computations the stresses for different concentrations of carbon in the low-carbon and chrome steel were calculated and the results are shown in the form of a curve in Fig. 10.

The carbon content of the chrome steel is higher than

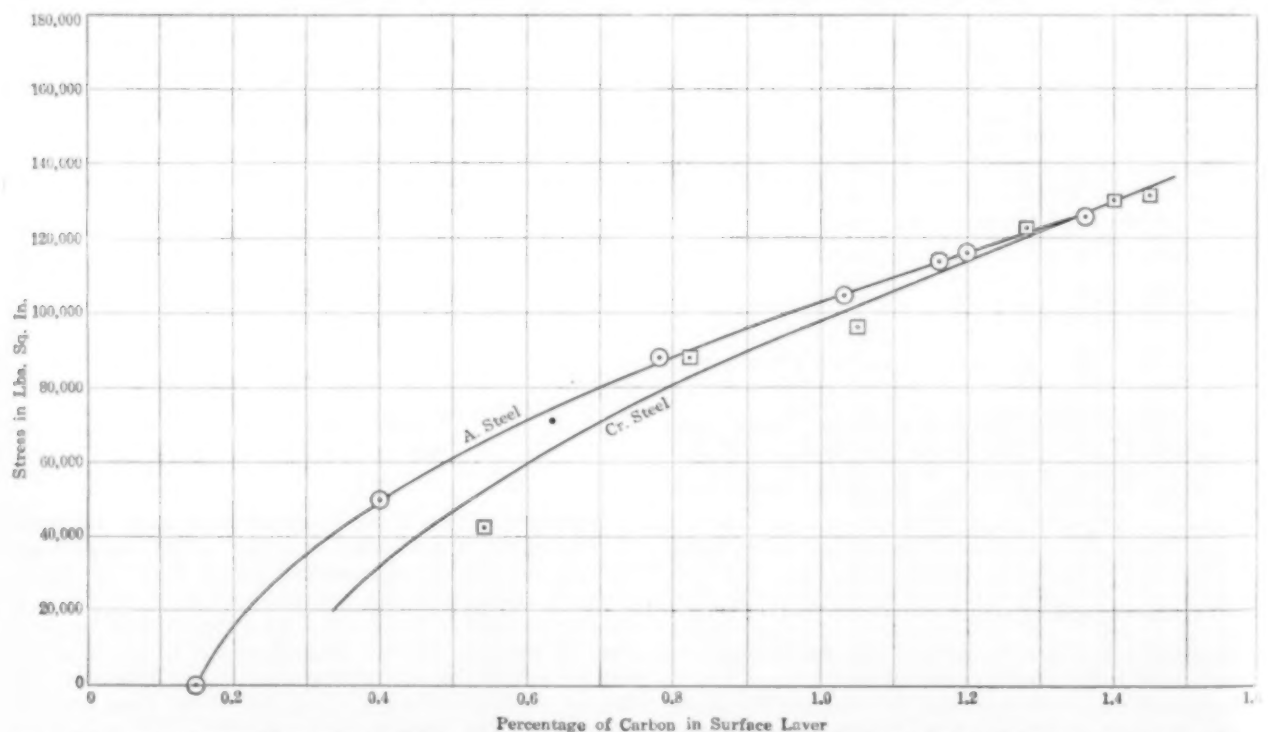


FIG. 10—STRESS-CONCENTRATION CURVES FOR A CASE-HARDENED CYLINDER; CASE 0.1 IN. THICK. DIAMETER 1 IN. QUENCHED AT 850 DEG. C.

what is generally found in material used for case-hardening purposes. Therefore, the specific gravity of the steel in the annealed condition was used for a basis in the calculations of the stresses. This value closely corresponds to the specific gravity of a low-carbon chrome steel after it has been hardened.

From the stress curves it is seen that very excessive strains are produced by the high-carbon cemented zones of both chrome and low-carbon steel.

The values of the stresses obtained by the above computations are higher than what actually occur in case-hardening because the rate of cooling during quenching, upon which the change in volume depends, is greater for the thin disks than it is for the larger machine parts. Lower values would also be obtained if the formula were refined so as to account for the increase in diameter of the core due to the deformation produced by the stresses. For the derivation of equation (7) this deformation was neglected, but more accurate results would have been obtained if it had been taken into account as was done by A. L. Jenkins in his analysis of the stresses produced in forced fits.* However, the difference in the rate of cooling and the refinement of the formula would not sufficiently reduce the value of the stresses to make thick cases and high concentration permissible.

Other stresses are also produced in hardening which may either act with or opposite to S_r . These stresses are produced by the thermal expansibility of steel. If a piece of steel is cooled rapidly, as by quenching, from a high temperature, the surface layer is cooled first and contracts upon the hot interior. In heating, the opposite is true. The exterior layer becomes heated first and expands before the temperature of the interior has been raised. During the quenching of most case-hardened parts, the contraction of the outer layer partly offsets the stress due to the higher specific gravity of the high carbon case. However, on reheating a case-hardened part the expansion of the outer layer increases S_r by an amount which is dependent on the rate of heating and on the coefficient of thermal expansion. For this reason, the rate of reheating case-hardened parts which are subjected to the double heat treatment must be low.

The reverse, however, holds good for nickel steel. During quenching, the forces produced by the contraction of the outer case acts in conjunction with the stresses due to the difference in the composition of the core and case. On heating a piece of case-hardened nickel steel, the two forces tend to counteract each other. Thus, for this steel, the rate of heating after the first quenching need not be so low.

Since two forces act in the same direction when case-hardened nickel-steel parts are quenched it would seem that the rate of cooling must be kept low in order to prevent the tension cracks, which are normal to the surface. This does not hold to any great extent because the coefficient of thermal expansion of steel is considerably lowered by the presence of nickel. Then too, the stresses caused by the difference in composition of the core and the cemented zones of nickel steel are small, due to the small variations in their specific gravity.

Conclusion

From the results of this investigation it can be concluded that exfoliation is caused by the difference in the volume changes of the core and the cemented zone which take place during the hardening of cemented parts; also that since the stresses which tend to produce exfoliation can be subjected to a rational and logical analysis; they can be kept below the safe limit by designing the parts to be cemented, with a case having a

thickness and a carbon concentration compatible with the material used.

In the design of machine parts most elaborate formulae are used to take care of the external stresses while the internal stresses are allowed to take care of themselves. Manufacturers are aware of this fact, but this neglect cannot, as yet, be overcome because the internal stresses are not thoroughly understood and data regarding them are not available. Although the data obtained in this investigation are not applicable without modification to machine design, for reasons stated above, the method for obtaining these necessary data and the manner of applying them have certainly been pointed out.

The results of this investigation also account for other phenomena besides exfoliation. The evil effect of the segregation of carbon in steel is probably due to the same forces which produce exfoliation; the carbon itself being only indirectly the cause of the failures in such steel. Segregation is less noticed in nickel steel because the stresses produced by the volume change are low and therefore failure in this steel seldom occurs. It is not likely that nickel in reality prevents the carbon from segregating as is commonly believed, but it rather obliterates the harmful effect of such segregations.

The carbon-concentration curves are of theoretical interest, because they verify the present theory regarding the equilibrium established in the cementation process and show that the cementation action of the gases enormously preponderate above the direct action of carbon in the solid state.

University of Cincinnati,
Cincinnati, Ohio

Electrical Porcelain*

By L. E. Barringer

President, American Ceramic Society

In joining this discussion concerning ceramic products I wish to first take advantage of such a gathering of chemists and engineers to explain the term "ceramics," as now understood by those immediately interested or engaged in ceramic engineering. Originally the term referred to strictly art wares such as might be found in museums or in Fifth Avenue shops, but during the past few years has been applied to the industrial and technical field concerned with the use or production of silicates. There are, of course, exceptions as in the making of magnesia brick in which no silicate is employed, or in the production of certain cements, but in general the ceramic industry may be defined as I have just indicated.

The three main classes of the ceramic industry are the clay, glass and cement industries and a smaller but very important branch is that of enameling metal wares for cooking, etc.

In the clay and cement industries use is made of silicates as raw materials.

In the glass and enamel industries silicates are produced from oxides, carbonates, feldspars, silica, etc.

There is no industry which can be more sharply or consistently defined than the ceramic industry and I am very anxious to see the term more generally and clearly understood among the engineering profession in general other than those immediately interested in ceramics.

CERAMIC INSULATION

In the electrical industry ceramic products (silicates), are employed extensively as insulating materials and I need only mention such substances as mica, slate, soap-

*Engineering News, March 17, 1910.

*An address made at the Feb. 9, 1917, meeting of the New York Section of the American Electrochemical Society, in joint session with the New York Section of the American Chemical Society and the Society of Chemical Industry.

stone, glass, porcelain and asbestos products to indicate immediately the extensive and varied use to which silicate or ceramic products are applied in the manufacture of electrical apparatus.

PORCELAIN FOR ELECTRICAL PURPOSES

This evening I am dealing with only one of these ceramic insulating products but probably the most important with the exception of mica, namely, electrical porcelain.

The art of making porcelain is practically as "old as the hills" and originated in China in very early times. The history of the development and progress of this highest of ceramic products is interwoven with the history of the world.

It was not until about 1852, however, that the use of porcelain was developed as electrical insulation. At that time attempts were being made to string telephone wires using gutta percha insulators. It was found that such material was not weather-resisting, however, and also that the sulphur mixed with the gutta percha rapidly corroded the copper wires. In experimenting it was found that adding clay to the mixture gave very much better results and that the more clay there was added the better the insulation. This logically led to using practically all clay and crude clay insulators were finally adopted. The gradual progress from such crude clay insulators to porcelain or the highest grade of clay insulator was natural and porcelain was finally employed for purposes of insulating overhead lines and any other places where a high-grade weather-resistant insulation was required.

Porcelain is preferable to and distinguished from other clay wares by possessing to a pre-eminent degree the properties of hardness, whiteness, high fusibility, translucency and density or impermeability.

Porcelain has a high dielectric strength and insulation resistance and a $\frac{1}{4}$ -in. thickness will usually not puncture under 70,000 volts and a $\frac{1}{2}$ -in. thickness under 100,000 volts. The increase of dielectric strength with thickness follows roughly a quadratic curve. As in all other insulating materials, both the dielectric strength and the insulation resistance fall with rise of temperature and at 300 deg. C. porcelain becomes a very poor insulator indeed. In fact, the dielectric strength begins to fall at 100 deg. C. and decreases very rapidly until the insulation is of a small order at 300 deg. C. The decrease of insulation resistance with rise of temperature is of the order 100 to 1 with rise of 51 deg. C.

The specific gravity of electrical porcelain is 2.4 and the coefficient of expansion 0.000004 per degree C. This coefficient of expansion is about one-third that of steel, one-quarter that of copper and one-fifth that of brass.

Porcelain is waterproof, weather-resistant, not attacked by oils, gases or vapors, shows no warping or shrinking with age, is readily formed or molded into the various intricate shapes required, is of comparatively low cost and has a pleasing appearance.

The crushing strength is high, averaging 20,000 lb. per square inch and the tensile strength ranges from 900 to 1800 per square inch.

From what I have said so far it might seem that porcelain was a splendid all-around insulating material and that there would be little or no necessity for the many other insulating materials which are employed in the electrical industry; but there are certain deficiencies in porcelain which prevent it from being the ideal insulation for all purposes.

In the first place, there is a lack of toughness in porcelain such as is required to withstand sudden shock or impact, or even the jar or vibration of certain pieces of apparatus. In using porcelain insulators on battle-

ships, for instance, it has been found that the gun fire will cause excessive breakage. The same is also true with reference to using porcelain insulators on electric locomotives or electric cars, where there is a considerable amount of jar or vibration. In electrical porcelain there is also little or no resistance to sudden heating or cooling and for this reason the material would not be suitable for use in controllers or rheostats or in other places where there is intermittent heating and cooling. It might be asked why electrical porcelain does not stand heating and cooling as well as chemical porcelain, but I would call your attention to the great difference in design. The thin and uniform walls of porcelain dishes used in the laboratory permit of their being heated through uniformly and quickly so that there is no great expansion differential. With the large irregular-shaped porcelains used in high-voltage insulation, however, any sudden heating causes local expansion and gives rise to cracking. The heat conductivity of porcelain is very low and a thick-walled piece will not heat through quickly.

There is also the drawback of non-flexibility and porcelain cannot be used for such purposes as insulating armature coils or other moving elements of electrical machinery where there is considerable bending and torsional strain.

Finally, metal parts cannot be imbedded or molded into place in porcelain as the high temperature used in burning will either melt the metals or else flux them with the silica of the porcelain mixture. In certain cases of insulation, therefore, the rigidity of construction cannot be secured with porcelain as with certain other molded materials.

The composition and method of manufacture of electrical porcelain is not unlike that of other porcelain wares, as ornamental porcelain, chemical porcelain, etc.

The materials employed in producing high-grade porcelain are kaolin, or china clay, ball clay, feldspar and silica.

The clays possess the valuable element of plasticity which permits of the ware being readily formed into the various shapes required. The clays have also the very valuable property of becoming indestructible upon firing. When clays are used alone, however, a porous mass or "body" is secured when the wares are fired unless the heat is carried to excessive temperatures which quickly melt or distort the pieces.

Feldspar is used as a flux to give a dense, vitrified body at a temperature readily attainable.

Flint is used as a stabilizer to extend the vitrifying range and to prevent the distortion of the pieces within a narrow temperature range as would result were feldspar and clay used alone.

All are familiar with the chemical changes which take place upon heating such a mixture as I have described. As the heat in the kiln increases the clay loses its combined water, this occurring within a temperature range of 600 to 900 deg. C. In the neighborhood of 1200 deg. C. the feldspar fuses and the clay begins to dissociate with the formation of sillimanite ($\text{Al}_2\text{O}_3, \text{SiO}_2$). As the temperature still further increases the quartz is slowly attacked or dissolved by the feldspar up to 1400 deg. C., when solution is practically complete.

The final product consists of glass or fused feldspar in which is dissolved quartz and the silica resulting from the dissociation of the clay, sillimanite crystals and more or less of residual or undissolved quartz, depending upon the final temperature, or degree of vitrification.

Professor Binns* has already told of the general

*The paper by Professor Binns was published in our issue of April 1, 1917, page 395.

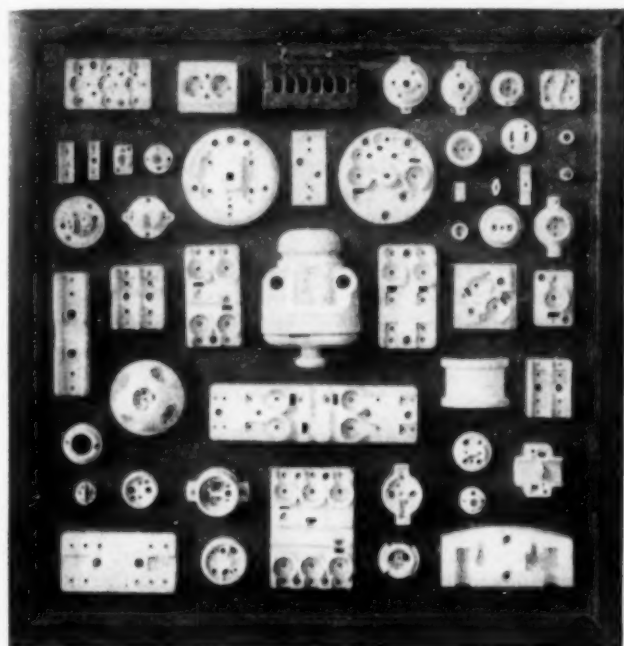


FIG. 1—DRY PROCESS PORCELAIN INSULATION

processes by which porcelain is manufactured and I will not repeat what he has said. For electrical porcelain the mixtures are prepared and handled practically along the same lines as has just been described by Professor Binns.

In the manufacture of electrical porcelain, however, the ware is classified into dry and wet processes, the former being that class of ware which is formed in steel dies and the latter that class of ware which is formed from the plastic porcelain mixture in the same manner as chemical or art porcelain. Figs. 1 and 2 illustrate both these classes of porcelain. The dry-process porcelain is used for low-voltage insulation and is seen in the form of cleats and knobs, etc., for the wiring of buildings for electric lighting. Wet-process porcelain is used for the making of insulators for high-voltage apparatus, as transformers, and high-tension switches and as insulators for high-voltage transmission lines. The wet-process porcelain is of considerably higher dielectric strength than the dry-process and is not absorbent. Wet-process porcelain will not absorb over $\frac{1}{4}$ of 1 per cent of water when immersed for forty-eight hours, whereas the dry-process may absorb as high as 1 per cent under the same conditions. The two classes of electrical porcelain are the same in composition but the difference in porosity and dielectric strength results from the different methods used in preparing the mixture.

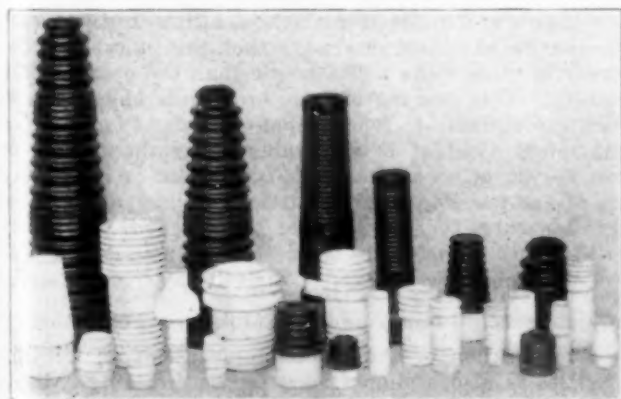


FIG. 2—WET-PROCESS PORCELAIN INSULATION



FIG. 3—CONTINUOUS KILN FROM DISCHARGE END

In the drying and burning of electrical porcelain there is no fundamental difference between the operations and the same operations in the handling of chemicals and art porcelains, and Professor Binns has already explained to you the general method of procedure.

I wish to call your particular attention, however, to an advanced type of kiln for firing porcelain. For many years the old bottle-shaped potter's kiln was used and all are no doubt familiar with this type of kiln. It produced the desired results but was extremely wasteful of heat. During the past few years types of continuous kilns have been devised and we are now operating a continuous kiln at Schenectady with very successful results and are saving about 50 per cent of the fuel required for operating the up-draft potter's kiln.

The kiln (Figs. 3 and 4) is a straight tunnel, 197 ft. long, with a fixed firing zone somewhat nearer the discharging end than the charging end. The ware is placed upon cars and moved through the firing zone to the cooling end. At the firing zone there are grates on either side. This combustion chamber is separated from the main tunnel by a narrow wall and the gases passed through tuyeres before entering the main tunnel. Air for combustion is preheated by passing through port holes at the discharge end. The air is heated by coming in contact with the outgoing cars of finished and cooling ware. Just before reaching the firing zone the flue is divided and part of the air (primary air), is deflected to beneath the grates to be used for combustion of the fuel. A second flue deflects a part of the preheated air (secondary air), into the main tunnel at the firing zone area where it serves for the combustion of incompletely consumed gases from the fire boxes. The gaseous products of combustion pass toward the receiving end of the kiln and serve to heat up the incoming cars of green or cold ware and then pass into



FIG. 4—SIDE VIEW, CONTINUOUS KILN

the main stack flue at the receiving end of the kiln. The stack temperature is only from 200 to 220 deg. C.

The temperature of burning is 1300 to 1400 deg. C. All ware is fired in saggers and a sand-seal protects the running gear of the cars from the burning gases.

Each car carries about 87 saggers 12 in. diameter of 6-in. high (inside). A kiln of the type under discussion is equivalent to about $3\frac{1}{2}$ of the ordinary potters' kilns of 14 ft. diameter. In addition to a saving in coal of about 50 per cent it has been found that the labor of handling or manipulating the kiln is slightly less and that the life of the saggers is increased.

This kiln represents a radical change and improvement in the method of firing, not only electrical porcelain, but ceramic wares of all kinds.

General Electric Co., Schenectady, N. Y.

Beet Molasses: Its Composition and Utilization*

By Sidney J. Osborn

General Chemist, Great Western Sugar Co.

Molasses is not only the most important by-product of beet sugar manufacture from a financial standpoint, but is also of particular interest chemically and from the point of view of the variety of ways in which it has been utilized.

In order to understand just what molasses is, let us consider the manner in which it is derived. Without going into any great detail regarding the manufacturing process, it might be said that the latter consists of two main operations, first the purification of the juice obtained from the beets, in which lime, carbon dioxide, and sulphur dioxide are the principal reagents used, and its concentration by multiple-effect evaporation to a syrupy condition, in which form it is commonly known as "thick juice." In the second part of the process this "thick juice" is subjected to fractional crystallization to obtain the sugar, that is as much of it as is possible to extract in this manner. It might be remarked that, in the process of crystallization in a sugar factory, peculiar difficulties are encountered in the high solubility of sugar and its tendency to form supersaturated solutions and in the great viscosity of the products which have to be handled. The methods of operation, which employ vacuum pans and crystallizers to produce the crystals, and centrifugal machines to separate them from the mother syrup, have been carried to a high degree of perfection under conditions which demand the handling of immense quantities of material with a minimum of trouble and expense, and are well worth the attention of those in other lines who have crystallization problems to solve.

As sugar is worth much more in the form of "granulated" than in the form of molasses we naturally try to crystallize out as much of it as possible, but there is an important limitation to the extent to which this can be carried. The impurities present in the juice, which are both organic and inorganic in character and are commonly for convenience designated as the "non-sugars," hold back a definite proportion of the sugar—in what way we shall examine later—so that it is impossible to carry the crystallization any farther when a certain ratio of sugar to non-sugar has been reached. This ratio, in the case of beet products, is that of about 60 parts of sugar to 40 parts of non-sugar. A reference to the analyses will make this clearer (Table I).

Molasses is then the final mother syrup obtained in the crystallization of sugar. It contains all the soluble impurities of the beet which have not been removed in the purification of the juice together with the sugar

associated with them. The importance of the molasses production will be realized when I say that of the sugar in the beet which enters the factory, 15 to 20 per cent passes out in the form of molasses.

The textbooks commonly distinguish between a "true" molasses and a "commercial" molasses. A true molasses is a mother syrup from which no more sugar can be crystallized out under the most favorable conditions of concentration and temperature. A commercial molasses is the molasses obtained in manufacturing operations in which the crystallization has been pushed to the limit that the apparatus and the time at disposal will permit, or the limit to which it is considered profitable to go. A commercial molasses is never a true molasses, but under efficient operating conditions approximates closely to it.

Theories of Molasses Formation

It has so far been mentioned that the non-sugar holds back or prevents a certain proportion of sugar from crystallizing, and this was the original theory of molasses formation, which was a mechanical one, viz., that the non-sugars exert a restraining power on the crystallization of the sugar, and that molasses is a super-saturated solution of sugar in water.

This theory, however, met with many objections, for, if the action of the non-sugar is merely inhibitive, it ought to be possible to push the crystallization almost indefinitely by suitable means, whereas we find that we reach very quickly a sharply defined limit beyond which crystallization will not take place. Let us consider also the following phenomenon. A saturated solution of sucrose, or pure sugar, at a definite temperature cannot dissolve any more sugar. If sodium chloride, however, or one of innumerable other salts, be added to the solution, not only will it dissolve but an additional amount of sucrose can also be dissolved in the same solution—in other words the solubility of sugar is greater in a salt solution than in water.

The study of such phenomena by many investigators resulted in the theories of beet and cane molasses formation which are now generally accepted. Herzfeld was led to the idea that beet molasses is a saturated solution of sugar in a non-sugar solution, or that it is a solution of sucrose-salt complexes, or compounds, which have a greater solubility than sugar alone. Greater details and definite proof of the existence of such compounds are lacking. However the hypothesis, as far as it goes, seems to meet most satisfactorily the conditions and phenomena which have been encountered.

The adjective "melassigenic," which as its derivation implies means "molasses forming," is frequently applied to the non-sugars. We have in discussing the theories of molasses formation spoken only of the melassigenic action of inorganic salts or non-sugars. It can hardly be denied that the organic non-sugars present in molasses have also a melassigenic action, although it has been demonstrated in various ways that the inorganic non-sugar is much more melassigenic than the organic non-sugar. This is a matter also of considerable commercial importance. It follows that, in order to obtain the maximum yield of crystallizable sugar, impurities or non-sugars of all kinds should be avoided or eliminated as far as possible, and in particular those of an inorganic nature, for every pound of non-sugar will carry with it into the molasses one and a half pounds of sugar which cannot be recovered directly as "granulated."

Commercial Importance of Molasses Formation

The question of the melassigenic action of the impurities is also of importance for determining a basis of settlement in transactions in commercial products such as raw sugar. The value of raw sugar depends

*A paper read before the Teknik Club, Denver, Col., Feb. 13, 1917.

mainly, not on the percentage of sucrose which it contains, but on the amount of "granulated" which can be obtained from it. A hundred pounds of Cuban Centrifugal, for example, which contains 96 per cent sugar by the polariscope test, will yield about 90 pounds of granulated. Of the other six pounds, some is lost in the refining process, but the greater part of it goes into the refinery molasses.

In Germany, where most of the beet sugar is still manufactured in small factories in the form of raw sugar and sold to large refineries, the yield of crystallizable sugar, or "rendement," as it is called, which is used as a basis of settlement, is calculated by subtracting five times the percentage of ash from the polarization (the percentage of sugar indicated by the polariscope).

Melassigenic Action of Various Non-Sugars

To return to the discussion of the melassigenic action of inorganic salts, it should be stated that, while early experiments made with pure sugar and salt solutions showed that sugar is more soluble in certain salt solutions than in water, in solutions of other salts sugar is less soluble, or, to put it another way, the addition of certain salts to a saturated sugar solution will cause some of the sugar to crystallize out.

We accordingly had classifications of the common inorganic salts as melassigenic and non-melassigenic, or as positive, negative, and indifferent "molasses formers." If this is the case, it is exceedingly important for the sugar manufacturer to know what salts are harmful and should be avoided as far as possible, and what salts might actually be beneficial by their presence.

However it was soon shown that while a particular salt in a solution of definite concentration might be classed as a negative molasses former on the basis of such experiments as were described above, at a higher concentration it might have exactly the opposite effect, further its action might be entirely different in a solution of a mixture of several other salts.

It is therefore regarded at present as exceedingly doubtful if any salt is to be classed as a negative molasses former. It is rather regarded that all non-sugars contribute to molasses formation in varying degrees, and this is undoubtedly the safest view to take.

Composition of Molasses

Let us now glance at the composition of molasses as shown in Table I, where the percentages of the ingredients are given as commonly determined in sugar analysis. The first two analyses are taken from Browne's "Handbook of Sugar Analysis," and the third is an average of a great many samples of "discard" molasses of the Great Western Sugar Company. Just what is meant by "discard" molasses will be explained later.

Table I—Molasses Analyses.

	Typical Cane.	Typical Beet.	Great Western Sugar Co., Discard Beet.
Water	20	20	20.4
Sucrose	30	50	49.3
Raffinose	None	Present	2.9
Invert sugar	32	Trace	Trace
Ash	6	10	11.9
Organic non-sugar	12	20	15.5
	100	100	100.0
Ratio sugar to non-sugar... 37½:62½		62½:37½	62:38
Ratio, sugar to ash..... 5:1		5:1	4.1:1
A saturated pure sugar solution at 20 deg. C. — 40 parts sugar to 20 parts water.			

With respect to beet molasses, the water which is determined by drying at 100-105 deg. C., amounts to about 20 per cent. The sucrose, which is determined with the polariscope, amounts to about 50 per cent. This is a figure worth remembering as it is the sugar content which gives molasses its chief value. This

sugar as we have previously seen, cannot be removed by direct crystallization, but is probably in the form of soluble sugar-salt complexes. Let us bear in mind, then, that beet molasses contains about half its weight of sugar.

A word about raffinose, also known as melitose or melitriose, which is likewise determined by polariscopic methods. Sucrose is represented by the formula $C_{12}H_{22}O_{11}$ and belongs to the class of disaccharides. Raffinose is also a carbohydrate and is a trisaccharide; its formula is $C_{18}H_{32}O_{16} + 5H_2O$. Raffinose is not a normal constituent of cane juice or cane molasses. It is, however, normally found in small amounts in the sugar beet, and becomes concentrated in the molasses. It should be stated, however, that the raffinose, as it is determined, is calculated simply from optical measurements made with the polariscope. It would be too long a digression to go into the matter fully here, but the consensus of opinion is that only a portion of what is reported as "raffinose" in Colorado molasses is actual raffinose, and that the remainder is an optically active, dextrorotatory gum, or a mixture of several such substances. The word "raffinose" is therefore to be regarded as the result of a certain determination rather than an actual percentage of a definite substance.

By the action of acids or certain enzymes, sucrose is hydrolyzed, or "inverted," as it is frequently called, and split up in the following manner. A molecule of sucrose ($C_{12}H_{22}O_{11}$) takes up a molecule of water and yields two molecules of simpler sugars, each having the formula $C_6H_{12}O_6$. These two sugars are isomeric; one of them is glucose or grape sugar, the chief constituent of corn syrup, or commercial glucose, the other is fructose, or fruit sugar. "Invert sugar" is simply a convenient expression for the mixture of equal parts of glucose and fructose produced by the inversion of sucrose. Invert sugar is not a normal constituent of beet juice or beet molasses and is not usually present in determinable quantities. It is on the other hand a normal constituent of the sugar cane and becomes concentrated in the molasses, where its amount is about equal to that of the sucrose present.

The ash, which is determined by ignition and is taken as a measure of the amount of inorganic non-sugars, amounts to about 10-13 per cent in beet molasses. The "organic non-sugar" is determined by difference and bears the balance of error made in the determination of the other constituents. The expression "organic non-sugar" covers a multitude of ignorance, especially as regards any quantitative data. It may, however, be said that the organic non-sugars of beet molasses consist largely of amino-acids or their derivatives and include such well known compounds as aspartic acid, glutaminic acid, and betain. There are no albuminoids present.

Cane Molasses

Little has so far been said about cane molasses, and to avoid attempting to cover too much ground it is not the object of this paper to deal extensively with it. There is one interesting relation between beet and cane molasses, however, which has been pointed out by Dr. C. A. Browne.

Recurring again to the theories of molasses formation, we see in Table I that the typical beet molasses contains 50 parts of sugar to 20 parts of water, where a saturated solution of pure sugar at ordinary temperature contains only about 40 parts of sugar to 20 parts of water. This greater solubility of sugar in beet molasses has been explained as due to the formation of sugar-salt complexes which have a greater solubility than sugar alone.

In cane molasses an apparently opposite condition ex-

ists. There is less sucrose than will saturate the amount of water present. We are indebted to Prinsen-Geerligs for a theory of cane molasses formation somewhat similar to that which has been given for beet molasses. Prinsen-Geerligs holds in brief that there exist in cane molasses compounds or complexes of salts and invert sugar, and that these complexes hold in combination a large amount of water of hydration which thus reduces the quantity of water available for solution of sucrose.

Table II.

	Original Cane Molasses	After Fer- mentation of Invert Sugar	B with 3 Parts Water Evaporated	Per- centage Composition of C.
	A	B	C	D
Water	20	20	12	20
Sucrose	30	30	30	50
Invert sugar	32	0	0	..
Ash	6	6	6	10
Organic non-sugar	12	12	12	20
Totals	100	98	60	100

Now the idea has been held by some that if the invert sugar of cane molasses could be removed or destroyed in some manner, an additional yield of crystallizable sucrose could be obtained. There are some alcohol producing organisms which do not secrete invertase and which in pure cultures will attack invert sugar but not sucrose. Assuming that all the invert sugar could be removed in this way from the typical cane molasses in Table I, without alteration of the sucrose, what would result? After the removal of the invert sugar and evaporation to the previous concentration, as shown in successive steps in Table II, the percentage composition would be exactly the same as that of the typical beet molasses in Table I. In other words the molasses would simply be changed from a cane to a beet type, from either of which no sugar will crystallize. The idea therefore that, by destroying the invert sugar in cane molasses, additional crystallizable sugar could be obtained is plainly fallacious if the accepted theories of molasses formation are correct. Invert sugar is accordingly not a melassigenic impurity.

Utilization of Beet Molasses

Having discussed the composition of beet molasses and the theories of its formation, let us now pass to its utilization. As molasses, it will be remembered, contains sugar to the extent of half its weight, it is usually the sugar, and often the sugar alone, which is the valuable constituent in any method of utilization. It must not be forgotten, however, that the ash contains about 50 per cent potash (K_2O), and other valuable products have been obtained from the non-sugars. For convenience let us divide the methods of utilization into the following groups: Cattle feeding, alcohol production, extraction processes, miscellaneous.

Cattle Feeding

The impurities of the sugar cane have a pleasant, aromatic flavor, and raw cane sugar and cane syrups are common articles of human diet. It is different with the impurities of the sugar beet. While man demands his beet sugar in a purified form, it is fortunate for the general economy that the steer is not so particular. After the sugar is extracted from the beet, the residue the pulp, is used for cattle feeding, and after all the pure sugar that can be obtained from the juice is crystallized out another by-product results, the molasses, which finds wide application for the same purpose.

Molasses, in its original state, is not in a suitable condition for feeding on account of its sticky condition. Like almost any other single article of food, it is also not a balanced ration in itself. It does furnish a carbohydrate ration in a highly concentrated form, and as such is very valuable when used in proper amounts and

in suitable mixtures. The nature of the materials with which it is mixed will naturally depend on the locality in which it is used. In Germany, if we may believe what we read, peat seems to be used a great deal, not on account of its food value, but on account of its absorptive power, as well as bran and various kinds of meals. In our own section of the country alfalfa meal is, of course, the chief material used. Molasses is also frequently mixed with beet pulp.

While beet molasses contains as much as 8 per cent crude protein, by which is meant the total nitrogen multiplied by 6.25, this consists of water-soluble nitrogenous compounds about which there is some difference of opinion, but which it is probably safest to regard as not having an important food value. The food value really lies in the 50 per cent of sugar which the molasses contains. It also seems to be generally recognized that the salts in the molasses have a distinct value in stimulating the appetite and the digestion, so that larger amounts of forage are eaten. While objectionable effects may be produced if molasses is fed in excessive amounts, in quantities which by experience have been found suitable it is a very valuable addition to the animal diet.

Alcohol Production

A considerable amount of beet molasses, especially abroad, is used for the production of alcohol. It is hardly necessary to go extensively into this subject, as the process of producing alcohol from various raw materials is very much the same. It may be noted that, as the raw material in beet molasses is already present as a fermentable sugar, it does not require a preliminary malting as in the case of grain or potatoes, where the starch has first to be converted into glucose and maltose by the action of diastase.

The molasses is simply diluted to a suitable concentration, viz., about 17 to 22 per cent dry substance, and is then acidified with sulphuric acid. The acidification has a double purpose. Beet molasses is generally alkaline and yeast does not work well in alkaline solutions, further the presence of the acid prevents the invasion of bacteria and the setting up of false fermentations. The solution is next inoculated with yeast and allowed to stand at an initial temperature of about 65 deg. Fahr. (18 deg. C.). As the fermentation progresses the temperature gradually rises, and in the course of 48 or 96 hours, when fermentation is complete, the alcohol is distilled off in the usual manner.

The yield is always considerably short of the theoretical, on account of side fermentations and loss of alcohol by evaporation. With good practice a yield of about $3\frac{3}{4}$ gallons of 95 per cent alcohol per 100 lbs. of molasses, or about 75 gallons per ton, is said to be obtained. This is a little over 80 per cent of the theoretical and corresponds to the results of experiments in the laboratories of the Great Western Sugar Co.

As a corollary under this heading might be mentioned the use of molasses for the production of vinegar, in which the fermentation is carried a step farther to the acetic acid stage, so-called "generators" being used, consisting of large casks in which a dilute alcohol solution is allowed to trickle over beechwood shavings with free access of air.

Molasses Processes

Methods of utilizing beet molasses have so far been dealt with in which the molasses is used in its original condition, as in cattle feeding, or in which the sugar in the molasses is changed by fermentation into other products such as alcohol and vinegar. Processes will now be considered by which the molasses is treated so as to render possible an additional yield of crystalliz-

able sugar from the sugar in the molasses. In the light of what has been said about the nature of molasses, it is evident that such processes must consist either in removing some of the impurities so as to increase the ratio of sugar to non-sugar present, or in precipitating the sugar out in a purified form, so as to separate it from the bulk of the impurities with which it is associated in the molasses. It is also evident that all these processes depend for their return on the difference in the selling price of sugar in the form of "granulated" and of molasses. As "granulated" becomes cheaper and molasses more expensive, a point may eventually be reached where the margin of difference is not sufficient to offset the operating cost of such processes.

OSMOSE PROCESS

An historical review would not be complete without mention of the osmose process. This is one of the oldest of the molasses processes and has been operated down to very recent times, but to the author's knowledge it is nowhere in operation in the world to-day. For this reason it will be alluded to only briefly.

The osmose process is based on the familiar principle of osmosis, according to which the crystalloids tend to diffuse readily through a porous membrane while the colloids have a low rate of diffusibility. In practice the apparatus used, which is called an "osmogene," consists of a series of hollow frames arranged in a long row somewhat resembling a filter press in appearance. The frames are separated from each other by sheets of parchment paper. The hot dilute molasses is introduced at one end and circulates through every alternate frame. Hot water, introduced at the other end, circulates in the opposite direction through the intervening frames. There is thus a series of chambers containing alternately molasses and water.

Although sugar is a crystalloid, it has a lower rate of diffusion than the salts which are present in the molasses. While a considerable amount of the sugar in the molasses diffuses into the water and is lost, a more than correspondingly increased amount of the salts present is eliminated in the same way, so that the molasses issuing from the osmogene contains a higher ratio of sugar to non-sugar than it did before treatment. By reboiling this syrup in a vacuum pan and subjecting it to crystallization, an additional amount of sugar will crystallize out until the former ratio is restored, i. e., the ratio which represents the point at which no more sugar will crystallize.

The loss of sugar which passes into the osmose waste water is high. The yield is low—for a small amount of low-grade sugar and a large amount of molasses are obtained. This molasses can be "osmosed" a second time, but this results in a lower yield than is obtained the first time, and involves further loss of sugar and additional expense. The only thing to be said in favor of the osmose process is the cheapness of the installation. On account of the high losses and low yields it has been gradually superseded by other processes.

EXTRACTION PROCESSES

When it is desired to separate a substance from a miscellaneous collection of impurities, a common procedure is to precipitate it in an insoluble form with a suitable reagent. When the compounds of certain of the sugars are examined one is struck with the immense number of compounds which are formed by certain sugars such as glucose and fructose; these range from the additive compounds with hydrocyanic acid, for example, to the well-known hydrazones and osazones which Emil Fischer used to such advantage in his classic work on the constitution of the sugars. Sucrose,

however, forms very few such compounds; it does not unite with hydrocyanic acid, nor does it form a hydrazone or osazone. There is, however, a well-defined series of compounds of sucrose with the oxides or hydroxides of the alkaline earths. These are the sucrates, or saccharates, of barium, strontium, and calcium, and are made use of in the various extraction processes employed to obtain crystallizable sugar from beet molasses. In all these processes the saccharate is precipitated in an insoluble form and filtered out. It is then suspended in water, or in some cases added directly to the beet juice, and is treated with carbon dioxide gas. Carbon dioxide readily decomposes the saccharate, the sugar going into solution, and the insoluble carbonate of the alkaline earth metal being formed. The latter is then filtered out, and the filtrate contains the sugar which can be recovered by crystallization.

It is also interesting to note that nowhere in the beet sugar manufacturing processes proper is the sugar precipitated and separated in an insoluble form. The juice obtained from the beets is treated in various ways to precipitate and eliminate some of the impurities, and the sugar is then separated out by crystallization. In the extraction processes, however, the sugar is actually precipitated as an insoluble saccharate, which is filtered out and decomposed by carbon dioxide gas in order to recover the sugar. The extraction processes are therefore of considerable interest chemically, and have offered unusual problems both in chemical and mechanical lines.

BARIUM PROCESS

Barium forms an insoluble monosaccharate, represented by the formula $C_{12}H_{22}O_{11} \cdot BaO$. Baryta was the first chemical employed for the desugarization of molasses, and satisfactory results are said to have been obtained as early as 1849. The process has, however, never had an extensive application. It has been used in recent years in Italy, but is probably not being operated during the war. It is in operation at a factory in Canada, at Wallaceburg, Ontario. This is to the writer's knowledge the only factory in the world where the barium process is now in use. I had an opportunity to visit this factory two years ago, so can give some first-hand information.

The barium process as operated at Wallaceburg is as follows: A single vessel serves for both the precipitation and filtration, which operates by gravity. These iron vessels are about 4 or 5 feet in diameter and 3 feet deep. They are open at the top and have a screen of about 60 mesh near the bottom which serves as the filtering medium. There is an outlet pipe at the bottom, with a valve.

The proper amount of barium hydrate is first introduced in the form of a milk and is followed by the undiluted molasses. The contents are then mixed with a wooden paddle until within two or three minutes the precipitate of barium saccharate has formed and the mass has assumed a pasty consistency. The outlet valve is then opened and the mother liquor allowed to drain off. The precipitate is very granular and is readily retained by the screen. The first runnings, which are cloudy from the saccharate precipitated beneath the screen, are caught in buckets and returned to the filter. The precipitate is washed by pouring upon the filter first the sweet water from a previous filter, and then water containing a little barium hydrate. The cycle of operations requires an hour and a half.

After the washing the vessel is tilted and the barium saccharate is dumped into a mixer where it is mixed with water to form a milk. This is pumped to a carbonation tank, where it is decomposed with carbon

dioxide gas from the lime kiln. The liquid is then pumped through a filter press to remove the insoluble barium carbonate, and the filtrate, which contains the sugar, is mixed with the factory juice, which may be beet juice or cane liquor, accordingly as the factory is operating on beets or raw cane sugar.

So far the process is simplicity itself and the installation is extremely cheap. The difficulty and expense lies in the regeneration of the barium oxide. The barium carbonate cake from the filter presses has to be converted into barium oxide in order that it may be used again for the precipitation of sugar. This requires an extremely high temperature, and so far the only feasible process which has been found and the one which is at present used is to heat the cake to the necessary temperature in an electric furnace. The Wallaceburg furnaces are arc furnaces with carbon electrodes and are operated intermittently. The barium oxide is taken from the furnace as a red hot, sintered mass. It is allowed to cool, and broken up and slacked with water.

In simplicity of operation, in respect to losses and the purity of the saccharate obtained, the barium process proper leaves nothing to be desired. It is the electric furnace recovery plant which makes the barium process expensive both in cost of installation and of operation. If this part of the process could be essentially cheapened, it would be a tremendous step forward.

A further point should be mentioned. In the sugar business one is greatly limited in the choice of reagents in two important respects. In the first place, as sugar itself is such a cheap commodity, any reagent used must be inexpensive, or at any rate be capable of being recovered and used over again without too great expense. Secondly, as sugar and molasses are food products, it is necessary to avoid the use of substances of a poisonous or injurious nature which might contaminate the products. Barium salts are regarded as poisonous and if used there should be no doubt of their complete elimination. All sugar house juices contain soluble sulphates, and therefore any small amounts of barium which are not eliminated in the treatment with carbon dioxide ought to be completely precipitated as barium sulphate in the factory process. The claim of

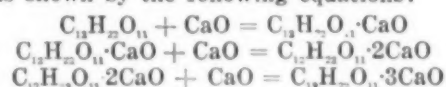
the Wallaceburg people that their sugar and molasses have always been absolutely free from barium, therefore, seems reasonable.

STRONTIA PROCESS.

Strontia forms both a monosaccharate ($C_{12}H_{22}O_{11} \cdot SrO + 5H_2O$) and a disaccharate ($C_{12}H_{22}O_{11} \cdot 2SrO$). The disaccharate, which is precipitated in a hot solution, is the compound made use of in the elaborate process by which a large proportion of the molasses production of Germany is desugarized. This is done at 5 large plants, each of which handles the molasses from a number of beet sugar factories'. Fig. 1 is a typical flow sheet of this process as used at the Dessau refinery in Germany. The illustration is self explanatory.

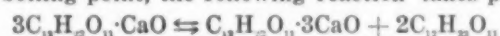
LIME PROCESSES

With calcium oxide, sugar forms three well-defined compounds, a mono-, di-, and tri-basic calcium saccharate, in which one molecule of sucrose is combined with one, two, and three molecules of calcium oxide respectively, as shown by the following equations:



The saccharates of lime are unstable compounds in that their constitution and solubility are so readily affected by changes in concentration and temperature.

If lime is added to a sugar solution in the proportion of one equivalent of CaO to one of sugar, the lime readily dissolves, forming the mono-saccharate, which is soluble in water but can be precipitated by the addition of alcohol. If, instead of adding alcohol, a solution of the mono-saccharate is heated to 80 deg. C., or close to the boiling point, the following reaction¹ takes place:



One-third of the sugar is precipitated as insoluble tri-calcium saccharate. On cooling, the saccharate re-dissolves. The reaction is therefore a reversible one, dependent on temperature. This reaction was used as the basis of a commercial molasses process at one time, but it has given way to the process which we are about to describe.

STEFFEN PROCESS

Now, if finely powdered quicklime is added to a sugar solution at a low temperature and in a mechanical device which is provided with means for keeping the solution cold and absorbing the heat developed by the reaction, also for distributing the lime slowly and as uniformly as possible into the solution while the latter is kept in rapid circulation—under these conditions the lime at first dissolves, forming the soluble mono-saccharate; in fact, up to this point the result is the same whether the lime is added in the form of caustic or slacked lime or without any of the special conditions which have been described.

Note these conditions particularly, for if simply an excess of lime be added to a sugar solution, only the mono-saccharate with an excess of calcium hydroxide is formed. If, however, the addition of finely powdered caustic lime is continued under the conditions described, the following result is obtained. The lime added continues at first also to dissolve, forming the di-saccharate which is soluble. Then when more lime has been added than is required for the formation of the di-saccharate, a white precipitate of tri-calcium saccharate begins to form, and by continuing the lime addition most of the sugar can be precipitated in this manner.

¹Taken from Stohmann-Schander, "Handbuch der zuckerfabrikation."

²For simplicity water of crystallization has been omitted in the formulas of the saccharates of lime.

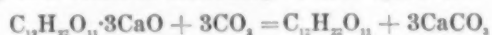


FIG. 1—STRONTIA PROCESS DESSAU REFINERY

It will be noted, therefore, that the insoluble tri-calcium saccharate can be formed in the cold as well as the hot. The cold process just described is known in Germany as the "Ausscheidungsverfahren," which translated literally means "separation process," but in this country it is always designated as the "Steffen process," after the man who developed it in a commercial way.

In practice the precipitation is made in a device known as a "cooler." This somewhat resembles a "standard" evaporator in appearance. It has a large central well, the space between the well and the sides of the cooler being filled up with several hundred vertical iron tubes between two tube sheets. A propeller at the bottom of the well draws the solution down through the well and forces it up through the tubes, thus maintaining a rapid circulation. The tubes are surrounded with cooling water circulated by a pump. The lime is conveyed to a hopper above, from which it is drawn into a box upon a platform scale, in order that the lime required for each cooler may be weighed accurately. It is then generally distributed into the cooler solution by means of a revolving bolter.

After the addition of the lime the liquid is pumped through a filter press, and the cake is washed with cold water. The filtrate, or "waste water," as it is called, goes to the sewer. The filter press cake, which contains the tri-saccharate, is diluted to the condition of a "milk" in a mixer, and the saccharate milk is then pumped to the main factory, where it is added directly to the beet juice. A factory which is not equipped with the Steffen process treats its raw juice with milk of lime and then with carbon dioxide gas. Where the Steffen process is installed, saccharate milk is simply substituted for milk of lime, and it is decomposed by carbon dioxide gas as has before been mentioned, insoluble calcium carbonate being formed and the sugar going into solution according to the equation:



The lime in the saccharate milk has the same purifying action on the juice as when milk of lime is used, and it carries with it the additional sugar which has been extracted from the molasses in the Steffen process.

FEATURES OF THE STEFFEN PROCESS

One essential feature for an economical operation of the Steffen process is a low lime addition. Theoretically only 49 parts of calcium oxide are required per 100 parts of sugar for the formation of calcium tri-saccharate. If an allowance be made for the lime dissolved in the mother liquor, which contains about 0.5 per cent sugar and has an alkalinity of about 0.75 per cent CaO, 100 parts of sugar ought to be precipitated with about 60 parts of calcium oxide. In a small laboratory cooler, using lime prepared in a laboratory furnace, no difficulty was encountered in precipitating over 90 per cent of the sugar with 65 to 70 parts of lime. A lime addition of below 100 is considered extremely good in practice, however, and is difficult to obtain.

When the Great Western Sugar Company first started work with the Steffen process, lime additions of 200 and more were not uncommon. The lime at that time was ground in large pebble mills such as are used in the cement industry and not over 60 per cent of the lime would pass a 200-mesh sieve. This meant that not only about half the lime was so much useless material, but, as the coarse lime developed so much heat when it slacked in the cooler, it raised the temperature of the solution and in this way seriously impaired the efficiency of the precipitation.

The introduction and perfection of a mill which pul-

verizes the lime and separates the finely ground particles by an air current marked a great step forward. It is now possible to obtain a large output of a product 98 or 99 per cent of which is finer than 200 mesh.

As one of the first essentials may be mentioned the use of limestone of high purity in order that the lime may have a high CaO content.

Reference also has been made to the fact that the lime must be in a caustic condition. This means that it must be well burnt, *i. e.*, free from carbonate, and it must contain as little hydrate as possible, *i. e.*, it should not be allowed to become air-slacked. In practice it is difficult to prepare lime which contains less than 1.5-2.0 per cent moisture. As one part of water is equivalent to 4.11 parts of calcium hydroxide, this means that 6 to 8 per cent of the lime, as we use it, is worthless on account of hydration.

It has also been said that the lime must be added slowly while the solution is kept in rapid circulation. Calcium oxide will combine with sugar in preference to water, but if at any point in the solution an excess of calcium oxide is present—this may be due to the presence of coarse lime or to an unequal distribution of fine lime—when all the available sugar has been used up the remainder of the calcium oxide will immediately slack, forming calcium hydroxide, in which condition it is useless for the precipitation of tri-saccharate. High lime addition may be caused by too slow circulation, by the presence of an excessive amount of foam which may accumulate on the surface of the solution and interfere with the lime distribution, and by imperfect bolters or lime distributors.

As regards temperature the lime addition is lower the closer the temperature of the solution is to 0 deg. C. Good results can, however, be obtained up to about 17 deg. C., and saccharate can be precipitated even above this, as shown in Fig. 2. In warm climates refrigerating machinery is almost essential for economical operation.

In Colorado, where there is an ample supply of cold river water during the greater part of the campaign, the installation of such machinery is hardly advisable.

As regards concentration, generally speaking the economy of lime is greater the more concentrated the solution is. Above a concentration of about 7 per cent sugar, however, the liquid becomes so heavy from the precipitated saccharate that a proper circulation cannot be maintained, and the lime addition apparently goes up for this reason. Colorado practice uses a cooler solution containing 5 to 7 per cent sugar. This means that the molasses must be previously diluted about 7 to 10 times.

As the precipitation of the tri-saccharate commences, the amount of sugar which is precipitated by a given unit of lime is at first small, it then rises to a maximum,

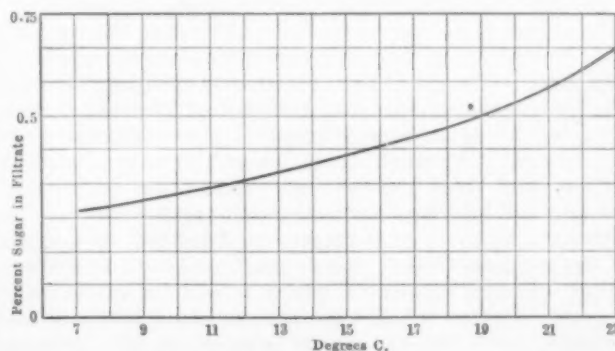


FIG. 2—PRECIPITATION OF SUGAR AT VARYING TEMPERATURE FROM A MOLASSES CONTAINING 5 PER CENT SUGAR

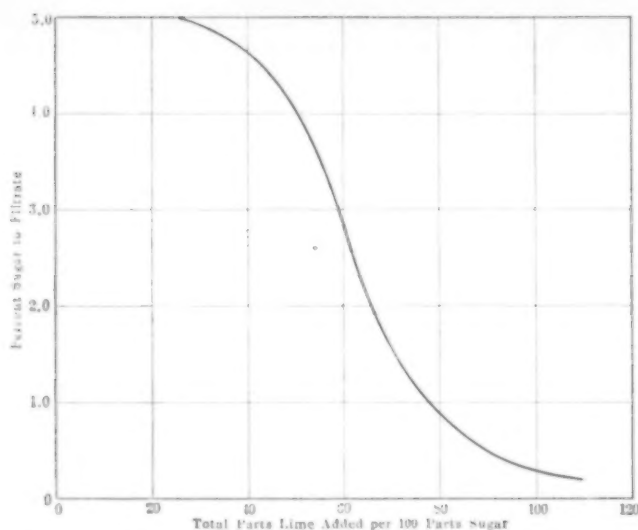


FIG. 3—PRECIPITATION OF SUGAR AT 5 DEG. C. WITH VARYING AMOUNTS OF LIME FROM A MOLASSES SOLUTION CONTAINING 5 PER CENT SUGAR

and from this point begins to decrease, so that, as the mother liquor becomes impoverished in sugar, more and more lime is required for the precipitation of a given amount of sugar. To reduce the sugar content of the mother liquor below about 0.4 per cent is difficult, even with a great excess of lime, and this is the point to which we generally aim to work in practice. If the original cooler solution contains, for example, 3 per cent sugar and the waste water, or filtrate, 0.4 per cent, it is evident that 93 per cent of the sugar originally present has been precipitated. See Fig. 3. For both curves the author is indebted to Messrs. Daniels and Roach.

FILTER PRESS WORK

The other essential for good Steffen work is the thorough washing of the filter press cake. This is much more difficult than with most cakes because the saccharate is to a considerable extent soluble in the washing medium, hence it tends to channel, and the filter press work is one part of the process that requires constant care and attention to obtain the best results.

"DISCARD" MOLASSES

It may be of interest to know how is determined what proportion of the molasses production shall be worked in the Steffen process and what proportion shall be sold for feeding. The Great Western Sugar Company aims to work all the molasses possible, but is limited in the following respect; there are some impurities which are very similar to calcium saccharate in their behavior, i. e., they are precipitated by lime in the Steffen house and contaminate the saccharate cake. In the factory they redissolve in the carbonation and appear again in the final molasses. The continuous working in the Steffen process of the entire output of molasses therefore results in an accumulation of these impurities in the process. Further, these impurities are of such a nature that they render the masscutes extremely viscous and interfere seriously with crystallization. To eliminate them it is necessary to "discard" a portion of the molasses from time to time, and this is the so-called "discard" molasses, which is sold for cattle feeding. If it were not for the accumulation of these impurities, probably the entire production of molasses would be treated with the exception of the amount required for local feeding.

This so-called "discard" molasses is in no wise inferior

to ordinary beet molasses for cattle feeding. In fact, it is a little superior, as it contains more carbohydrates and less ash.

The Steffen process is operated at present to only a very limited extent abroad, but in this country it is used to desugarize a large part of the beet molasses. It is quite common for factories not provided with the Steffen process to ship their molasses in tank cars to other factories equipped with the process, providing the distance is not so great as to involve too high a freight rate. In fact, in order to avoid a large number of small units, installations are generally planned in this manner.

COMPARISON OF SACCHARATE PROCESSES

A brief comparison of the three saccharate processes may prove of interest. The cost of installation of the Steffen process is cheaper than that of either the barium or strontium processes, although the chief cost of the barium process lies in the electric furnace installation, and, if the regeneration of the barium oxide could be sufficiently cheapened, it might then have the lowest initial cost of the three.

The great advantage of the Steffen process lies in the fact that it is so well adapted for use in direct conjunction with a beet sugar factory. To explain what I mean, consider the barium process for example. After the precipitation of the barium saccharate the latter not only has to be decomposed in a special carbonation tank in order to recover the barium, but the factory has to use lime in addition to purify the juice. With the Steffen process the lime serves a dual role. It is used to extract sugar from the molasses in the form of saccharate and it serves later also for the purification of the beet juice.

The great disadvantage of the Steffen process is that it yields saccharate of the lowest purity, and consequently the smallest eventual yield of "granulated." For example, a sample of discard molasses yielded juices* of the following purity ("true" purity) after the formation of the saccharate and its decomposition with carbon dioxide gas: Barium saccharate, 93.05 per cent; strontium saccharate, 88.33 per cent; calcium saccharate, 81.22 per cent.

These purities are lower than would ordinarily be obtained because in the type of molasses used there is an accumulation of impurities to such an extent that it would be discarded and not again put through the Steffen process, but they are cited for the comparison. With fresh molasses, barium saccharate of 98 purity and calcium saccharate of 90 purity are not uncommon.

In spite of the much lower purity of the calcium saccharate, the writer is convinced the advantages of the Steffen process are such as to render it the most profitable for the ordinary beet sugar factory.

There are also some interesting contrasts that can be drawn. For example: in the commercial processes, barium is precipitated as the mono-saccharate, strontium as the di-saccharate, and calcium as the tri-saccharate. The strontium saccharate is precipitated hot, the barium at about 40 or 50 deg. C., and the calcium saccharate in the cold. In the barium process the molasses is used without dilution, in the Steffen process it is diluted with several times its weight of water, while in the strontium process the dilution is intermediate between the two. Finally, the strontium process is used by Germany, the barium process by Great Britain as exemplified in a Canadian factory, and the Steffen process by the United States.

SUGGESTED APPLICATION IN "FLOTATION"

There is just one afterthought. All of us have heard

*Daniels and Roach.

much of "flotation" and some of us are perhaps directly interested in it. In the flotation process the object is the production of a large amount of oily foam, and such substances as oils, acids and alkalies are said to be added to produce it.

In the Steffen process more or less foam is produced and much work is required to avoid it. This foam is extremely tenacious. The author has seen a Steffen house almost at a standstill from being filled up with foam, and if much is accumulated about the only thing to be done is to put men to work with shovels and wheelbarrows to haul it outside. The thought has occurred to the writer that beet molasses, to which a little lime has been added, might be an ideal foam producer for the flotation process, and it could be used in quite a dilute condition.

Recovery of Potash

In methods of utilizing beet molasses mention has been made only of the sugar. Among other valuable constituents is potash, which constitutes about 50 per cent of the ash (50 per cent KO). Potash has been recovered from beet molasses for a great many years, and in these days when muriate of potash has increased in price from \$40 to \$400 a ton the subject has, of course, excited considerable interest.

It is usually customary where potash is recovered to start with the waste water of one of the extraction processes, or the residues of a molasses distillery. In this way the sugar is first utilized and the potash is then obtained.

Potash is not being recovered to any extent in this manner in the United States, but, like many other industries for the lack of which American chemists have been soundly berated, there is no mystery about it. Starting with Steffen waste water, the first step necessary is to carbonate it to remove the lime which would otherwise scale up the evaporator, and then to concentrate it in a multiple-effect evaporator. It may be sold in this form to fertilizer manufacturers or it may then be burnt to an ash in a furnace with considerable reduction of bulk.

If sold as a concentrated liquor, the value will be based on both the ammonia (nitrogen) and potash content, while if it is ignited the nitrogen will be lost, but an ash can be obtained which contains 50 per cent KO, largely in the form of potassium carbonate. Market conditions will determine in which form it is better to produce it.

It is entirely a commercial proposition to calculate whether the cost of production, freight, etc., is sufficient to yield a fair return. In the case of the Great Western Sugar Company there is no close market for the product, and while almost any beet sugar factory could have paid for a potash recovery plant in one year with potash at war prices, there has been a natural hesitation to invest money in plants of this kind which might be ready for the scrap heap if the war should end at any time, as the installation costs run into fairly high figures.

It is possible that the company mentioned may yet do something in this line. At least three factories in North America are already utilizing their waste water in this way. Whether they will be able to continue to do so after the war in all cases is questionable.

Miscellaneous Processes

It has been proposed at one time or another to obtain almost anything from beet molasses with the possible exception of radium. The author, however, has no desire to weary the reader with a recital of all these processes, real and imaginary. It might, however, be mentioned that beet molasses contains a considerable

quantity of betain, which is obtained from it commercially for medicinal purposes.

DESSAU PROCESS

In conclusion, mention should be made of the Dessau process, for it is characteristic of the thoroughness with which the Germans do things.

The Dessau process is operated, or at any rate has been recently operated, at two or three large plants in Germany, and employs for its raw material the waste water from the strontia process. This waste water is concentrated and subjected to distillation in a closed system. The gases, which among other things contain a considerable part of the nitrogen in the form of trimethylamine, are then passed through a "superheater" and heated to a high temperature, something like 1000 deg. C. As a result a rearrangement takes place which no one fully understands, and a considerable amount of hydrocyanic acid is formed. The gases also contain a large amount of the nitrogen in the form of ammonia. After removal of the tar the ammonia is then absorbed in sulphuric acid, the hydrocyanic acid in caustic soda, forming sodium cyanide, and the unabsorbed gases, which are combustible and have a high heating value, are used to supply heat for the process.

Very little has been published about this process. The writer has succeeded, in laboratory experiments, in obtaining one-fourth of the nitrogen as cyanide and one-fourth as ammonia. This corresponds with the yields as stated at that time, although it is possible that since then the efficiency has been improved.

To recapitulate, the products of the Dessau process are as follows: Crude potash (the residue in the stills), tar, ammonium sulphate, sodium cyanide and combustible gases, used in the process.

In these days when a serious shortage of cyanide is threatened in this country it may therefore interest some of the metallurgists to know that some of the cheap cyanide which they enjoyed before the war had its origin in a humble plant which is responsible for other things besides the sugar which it so abundantly produces.

Another Tin Smelter for the United States

About a year ago the American Smelting & Refining Company completed a tin smelting and refining plant at its Perth Amboy, N. J., works and has since been producing tin successfully from Bolivian and other foreign ores by a combination smelting and electrolytic refining process.

The National Lead Company concluded some important developments last year in the purchase of one-half of the capital stock of Williams, Harvey & Company, Limited, the largest tin smelters in Europe, having two plants in England, located at Liverpool and Hayle, Cornwall. The purchase contemplated the erection of a tin smelting plant in the United States, which will be operated in connection with the English company. An American company has been incorporated under the corporate name Williams Harvey Corporation to transact the business in the United States. The National Lead Company expends over \$10,000,000 a year in the purchase of tin which it markets in the form of solder, type metals, tin pipe, babbitt metals and other articles. The company has for many years smelted scrap tin and tin drosses. It has also experimented for several years with the smelting of tin ores in the belief that the tin ores of Bolivia, shipped through the Panama Canal, should logically be smelted in the United States for domestic consumption. A site of nine acres has been purchased on Mill Basin, Jamaica Bay, Long Island, and plans are under preparation for a large plant.

Some Studies on the Methods of Recovering Antimony from its Ores by Volatilization Processes*

By J. A. DeCew

Antimony sometimes occurs native associated with the metals, silver, iron and arsenic and in a number of minerals composed of these and other metals, but the chief ore is the sulphide stibnite (Sb_2S_3).

It may also occur in the form of oxide, either trioxide (Sb_2O_3) as valentinite or senarmontite, or the tetroxide (Sb_2O_4) as cervantite.

If the oxide ores are rich or can be concentrated, the metal can be recovered from them by fusion with reducing agents, but there is no profitable means of treating directly a low-grade oxide ore. The rich sulphide ores may be treated successfully by reduction processes, and are classified as smelting ores when they contain over 50 per cent of metal content.

These minerals of antimony are generally found in lenticular masses of varying thickness, carried in veins of either quartz or calcite.

As there are very few deposits of rich or high-grade ores in either Canada or the United States, any metallurgical process working on domestic ores must either follow a concentration treatment or must be adapted to the treatment of low-grade ores, at low cost and with reasonable efficiency.

VOLATILIZATION PROCESSES

Owing to the fact that the sulphide of antimony burns readily to the oxide Sb_2O_3 , and that both the sulphide and the trioxide are quite volatile, methods of treating these low-grade sulphide ores by combustion have been developed and used both in Europe and China. The mineralized oxides, however, as found in nature, are not sufficiently volatile to be treated by this process.

In the combustion process, the sulphur in the sulphide first burns to SO_2 , and then with rise in temperature the antimony Sb burns to Sb_2O_3 . These gases pass from the zone of combustion along with the excess air, and with reduction in temperature, the antimony oxide slowly leaves the gaseous form and becomes white fume. The completeness with which this oxide is transferred from the gaseous to the solid phase and the formation of solids having the right physical character are the essential elements of efficient recovery, although the problem of obtaining complete combustion of the ore is also very important.

COMBUSTION DIFFICULTIES

The burning of antimony sulphide is a simple reaction, but the accomplishment by ordinary means is quite difficult. For example, when the ore is burned in a stack furnace such as is shown in Fig. 1, it is not possible to maintain a uniform temperature in the charge. The bottom of the furnace will contain burned-out ore which is cooled by the draft of air supplied to the furnace. The central part of the zone of combustion will have the highest temperature, while the top part of the furnace will hold the freshly charged ore which will be but partially ignited and surrounded with gases poorer in oxygen. The conditions for satisfactory combustion exist, therefore, in only a limited part of the furnace.

Moreover, the properties of this mineral are peculiar. The sulphur ignites at a temperature near 200 deg. C. and the antimony at about 300 deg. C. The stibnite will melt at a temperature around 550 deg. C. and this is obviously much below the temperature resulting from

combustion. As a result a piece of rich ore would fuse and drop out of the zone of combustion before complete oxidation could take place. On the other hand, the sulphide begins to boil or vaporize at about 600 deg. C., so that unless the furnace is fed with a large excess of air, it is likely to distill over partially oxidized and thus become an impurity in the oxide.

There is another factor to consider and this is the fusibility of the associated vein matter and country rock. If the ore is associated with a decrepitating quartz, the rock containing the mineral will break up in the furnace and expose the mineral to oxidation, but if this quartz or associated rock fuses at the temperatures existing in the combustion zone, then the entire charge may fuse together, retarding combustion and blocking the furnace. On the other hand, if the vein matter consists mainly of a carbonate mineral such as calcite, then the difficulties resulting from fusion will be greatly reduced, but the gases of combustion will be greatly diluted by the liberation of carbonic acid. In any event a large oxygen excess is required, owing to the fact that the air will not pass uniformly through the ore mass and also because it is necessary to transfer the oxide gases quickly from the furnace to the condensing chambers.

OPERATING PRACTICE

In the shaft furnace shown about five volumes of air are used to one that is theoretically required, or about one-fifth of the oxygen in the air supply is actually combined with the sulphur and antimony and carbon in the ore. This is when an ore averaging about 10 per cent metallic content is used and when 4 per cent of coke is charged with the ore. The coke supply is required in order to maintain the combustion temperature in the furnace and extend its combustion area. The presence of this coke in contact with the ore, although it is a common practice, does not seem to have a proper theoretical basis, for it is only partially consumed during the time required for the ore to pass through the combustion zone, and it increases the possibility of local over-heating when combustion conditions are favorable. If this fuel were used to heat the air supply to about the ignition temperature of the ores, one would reasonably expect to have more uniform furnace conditions than that obtained in the ordinary furnace.

ROASTING FURNACES

The process of recovery of antimony by the production of the volatile oxide was developed in France by several inventors. One inventor named Hering used a reverberatory furnace for roasting, while another, Plews, used a revolving furnace heated with an oil or gas blast, which could be regulated to produce alternately an oxidizing or reducing flame. The only type known to have been used in Canada is the Herrenscheidt or stack furnace, although it would seem that a properly designed revolving furnace would be well adapted to the roasting of these ores, because in such a type the combustion of the extra fuel required takes place externally and there should be more complete combustion with less trouble from ore fusion.

If the stack furnace is properly designed, so that the temperature in the central portion of the ore does not produce caking from fusion, and if the depth of the combustion zone be so regulated that the antimony in the ore is completely volatilized and burned, then its efficiency would be quite equal to any other type and it would be of simple construction. In order to obtain these results, the furnace should be relatively deep and not too large in diameter. The area should increase with the depth so that even in case of fusion the ore would not be held up by the side walls. When ores does

*A paper read before the Canadian Society of Civil Engineers on March 15, 1917.

cake in a furnace it must be broken down by rods inserted from the top of the furnace, and this not only results in loss of oxide, but is dangerous to the men.

CONDENSATION OF OXIDE PRODUCED

After the antimony sulphide is converted to antimony trioxide (Sb_2O_3) and sulphurous acid (SO_2) the problems of condensation and recovery of the oxide are the chief consideration. To accomplish this completely and efficiently is exceedingly difficult, owing to the fact that the conversion of the oxide from the gaseous to the solid state takes place more slowly as the oxide condenses because of the reduction in the vapor pressure of the oxide. The boiling point of Sb_2O_3 is 1550 deg. C., but it is molten at red heat, so that any oxide which separates from the vapor form at temperatures above 750 deg. C. will appear as liquid particles and will build up upon the condensing surfaces in very hard and dense masses called coral oxide. Such material is very hard to grind and it cannot be marketed in this form as oxide,

nor can it be converted to metal as efficiently as can the snow-like deposits formed at lower temperatures. When the oxide is changing from the gaseous to the solid phase at temperatures below the point of fusion, it first forms a fog or fume, in the same way that a solid will separate from aqueous solution forming minute ultra-microscopic or colloidal particles. These exhibit the Brownian movement, which is the rapid vibration of individual particles, observed in all colloidal dispersions. These minute solids although in a gaseous medium will exert an osmotic pressure, similar to that of colloidal particles in an aqueous medium. This osmotic pressure resists the effect of gravity, and a state of equilibrium will be established between the two forces, which will have a selective influence upon the particles. The Brownian movement will cease and the osmotic pressure become negligible when the particle grows to a diameter of 10 microns, which is just about the visibility of the naked eye. Any particles larger than this would be acted on only by gravity and will settle in a reasonable

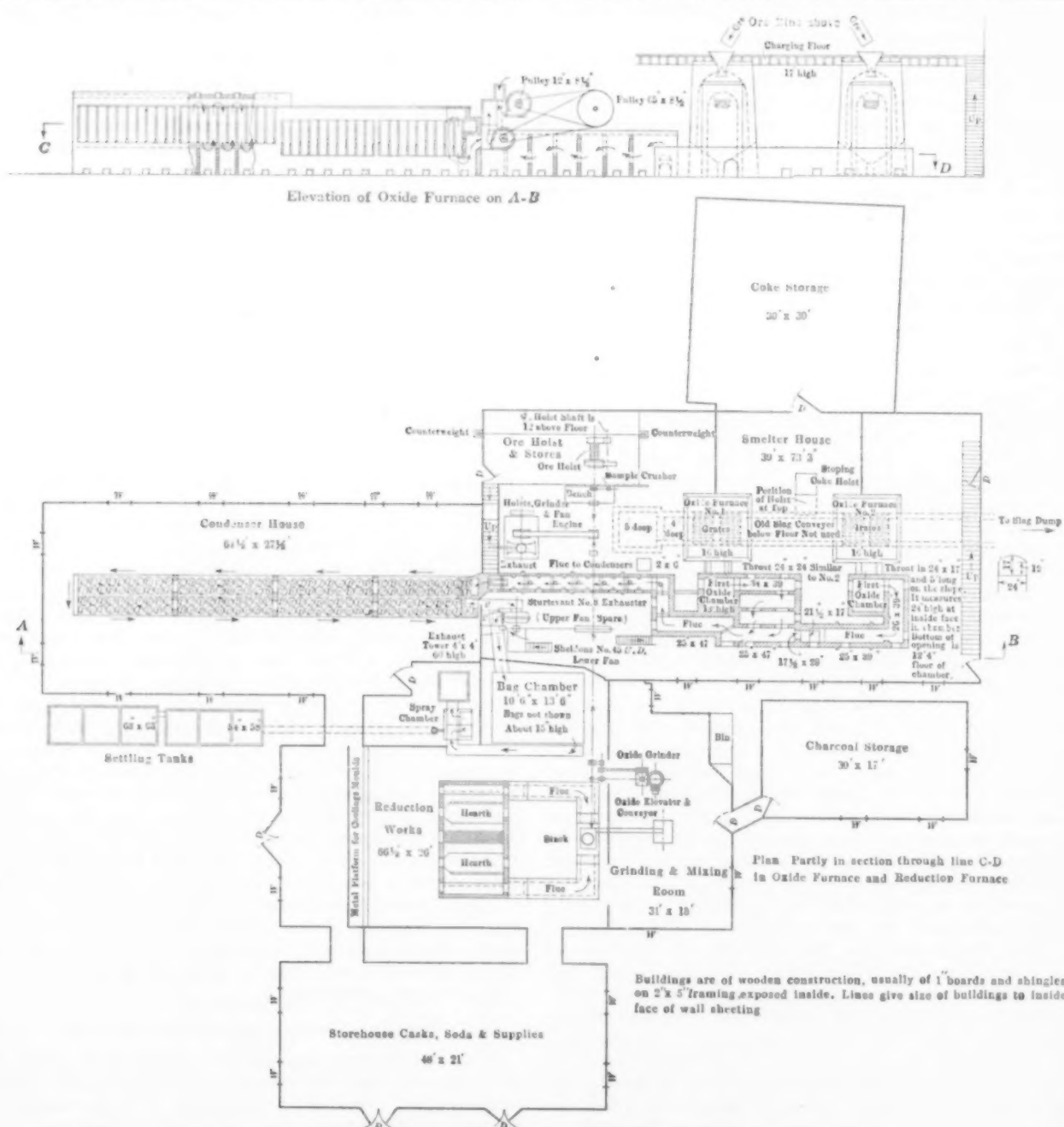


FIG. 1—ELEVATION OF STACK FURNACE AND PLAN OF COMPLETE PLANT

time. Among all of these particles there is a strong electro-repulsion, owing to the fact that they carry similar electric charges. Each particle is surrounded with a layer of air or gas, which also seems effected by the electric charge, and when these particles finally do settle upon each other, they do not actually come into contact, but are held apart by a film of gas. While in this condition they roll upon each other with great facility, and the density of the oxide is very low.

Considerable mechanical pressure and agitation is required to increase the density of such an oxide to any appreciable extent. When a substance is in an aqueous colloidal solution, which is the liquid solid phase, electrolytes have the property of discharging the electrical properties of these colloidal particles, but there is no such ready means of destroying the electrical properties of particles formed in the cooling of a dry gas. The rate at which the gas is cooled, however, has an influence upon the size of these particles. When the gas solidifies slowly there is a high degree of dispersion of the fume resulting in the formation of fine oxide, but when the entire antimony vapor is quickly solidified a denser oxide must be formed, because the dispersion means being constant the concentration must be greater. The condensation of the oxide may take place over a wide range of temperature, the amount remaining as gas at any given time being a function of the temperature and the vapor pressure. In order therefore to obtain a good recovery of oxide, it is necessary to bring the gases to a low temperature in the shortest possible time. This is difficult because a dry gas is a poor conductor of heat, so that considerable surface contact will be required to obtain a quick and uniform cooling. These gases, of course, are always dry as long as the temperature is over 100 deg. C. even if water vapor is present.

In order to recover the solid oxide by means of sedimentation or dust collecting devices, the original velocity of the gases must be very greatly reduced. As the volume of air passing through the ordinary furnace is about five times that which is theoretically required, and this volume is considerably increased by being raised to higher temperatures, and being also augmented by any air leaks in the condensing system, a very large condensing area is required in order to reduce the velocity of the gases to the point that will allow the finely divided particles of oxide to settle by gravity. Otherwise they will be carried entirely through the ordinary system regardless of its length, being held in suspension partly by air currents and partly by osmotic pressure. Mixing the gases with water vapor and then rapidly cooling them to a temperature at which the water will be condensed might have the effect of reducing the tendency of the condensed oxide particles to repel each other so that they could pack together in a mass, but under ordinary dry cooling conditions each particle of dust seems to have an electrical charge which repels all other particles whether liquid or solid. If, therefore, an endeavor be made to separate these gas-suspended particles by passing the gases through a scrubber containing water sprays, it will be found that a portion of the solid particles will be knocked down mechanically by the weight of the liquid particles, but owing to the surface tension of these liquid particles, the solids do not become wet for some time. There is in fact a repulsion rather than an affinity between the two substances, and as a result the efficiency of this type of scrubber is in such a case much lower than one would anticipate. The use of a water scrubber in the recovery of antimony oxide is only to be recommended for the treatment of those gases which have not yielded up their suspended solids by other means. The reason for this is that the oxide is not marketable in the wet state and it is a very difficult

product to dry. After it is dried it will be in the form of hard cake that must be finely ground before it can be reduced to metal in the reverberatory furnace.

The limitation of the efficiency of dry condensing systems is apparent when it is remembered that from the combustion of antimony ores the total volume of gas is very large, representing about 50,000 cu. ft. of gas to 1 ton of ore containing 10 per cent antimony (Sb), and also when it is remembered that the velocity of the falling particles is proportional to the square of their radii. It has been found that this law applies even to microscopic particles as small as $1/10$ of a micron and even for molecules no larger than $1/1000$ micron. The falling velocity under the influence of gravity of all particles under 10 microns in diameter, will be very slow, and if the oxides exist in this degree of fineness other means than ordinary sedimentation must be devised.

Methods have been recently used in the separation of such very fine particles from a liquid medium by means of the application of centrifugal force. By the use of a very rapidly moving rotor, it was found that a force could be developed equal to 40,000 times that of gravity. By such a force ultra-microscopic particles can be separated from a liquid medium, and if a centrifugal machine were devised for the separation of solids from a gaseous medium, which could handle a considerable volume of gas, the problem of collecting antimony oxide fumes would be a comparatively simple one. This principle is mentioned as one having possibilities in connection with future developments, rather than one for immediate application.

There is already established a very successful process for the collecting of all solid or liquid particles existing in the finely dispersed condition of fume or smoke. This system is known as the "Cottrell process," and is an exploitation of the electric properties of the individual particles above described, so that by means of electric charges passing through the gaseous medium, the particles are all gathered together at one of the poles. The process is very simply carried out by suspending a series of wires in a series of pipes and through these the gases carrying the solids are allowed to pass. High voltage electric currents are then passed from the wires to the pipes, and as a result all the particles suspended in the gases are attracted to the sides of the pipes and held there. These collections are loosened by mechanical agitation applied from time to time and the product drops from the pipes into containers below. (Fig. 2 shows such a condenser which has recently been designed for antimony fumes.) This process is now rapidly replacing all inefficient types of sedimenting systems, and is also recovering many products which have heretofore been entirely unobtainable by other means. As applied to the recovery of antimony oxides, it is probable that the high velocity with which these particles would be withdrawn from the gaseous medium from which they are condensed would pack them together on the sides of the pipes in a more dense mass than would be possible by any gravity separation. For a given density the state of subdivision in the electrically recovered product would be much greater than in that from the gravity separation, for in the latter the higher density would only be obtained by an accumulation of heavy particles.

DESIRABLE PROPERTIES OF THE TRIOXIDE

The trioxide is in demand for ceramic work owing to its fusibility and its property of producing a white opaque glass. One of its large uses is in the manufacture of white enamel ware, and for this purpose it is first blended while dry with other substances. Although

color, purity and fineness are important properties, yet the specific gravity is also a factor because the oxide may be so light that it is difficult to work with it. There are always ways of increasing the density of a product such as this by mechanical means, but if it could be recovered in such a manner that it would be both fine and dense, such a process would be much superior. Electrical precipitation seems to promise the best results in this connection.

When antimony sulphide is heated to a temperature above 350 deg. C. it burns to antimony trioxide and sulphur dioxide. The antimony trioxide is fusible and volatilizes at temperatures above 700 deg. C. If the trioxide is heated to high temperatures in presence of air the tetroxide is formed. The tetroxide is non-fusible and non-volatile and insoluble in mineral acids with the exception of concentrated hydrochloric acid.

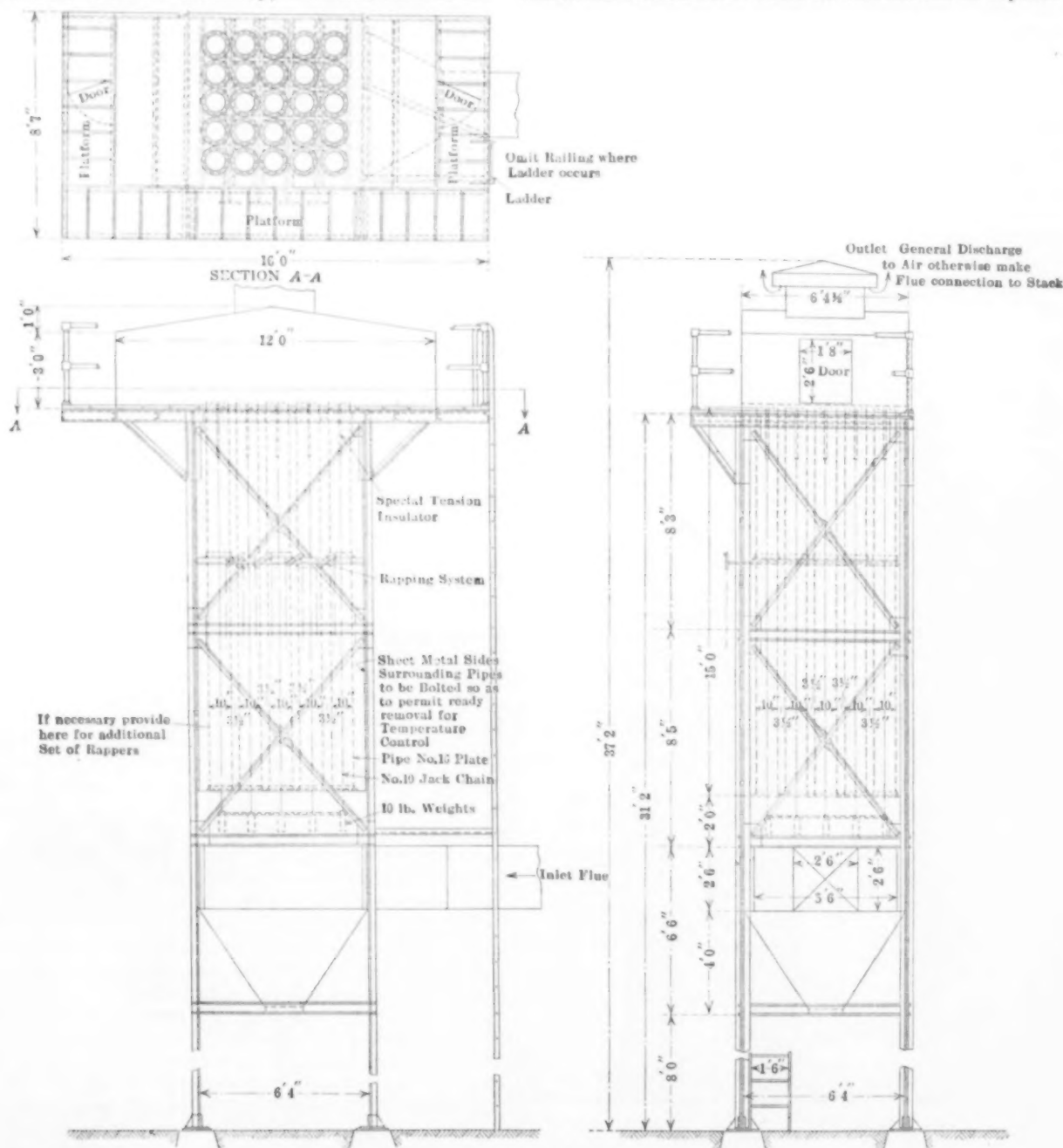
ARSENIC-ANTIMONY COMBUSTION IN OXIDE FORM

If another metal such as arsenic is oxidized in the same furnace with the antimony, an antimonate of ar-

senic may be formed which takes on the properties of the antimony oxide. The arsenious oxide combined in this form is insoluble in solutions of either caustic or carbonate alkalies.

From the experience of the author in dealing with an antimony ore containing arsenical pyrites distributed through the gangue rock, it was found that about one-half of the arsenious oxide formed became united with the antimony oxide to form an antimonate, which was insoluble in aqueous alkali. The other half remained as arsenious oxide, and could be extracted by means of an alkaline wash.

As arsenic is sometimes considered a commercial impurity in antimony, an efficient process of elimination is desirable, but the properties of the two metals are so similar that the problem is very difficult. As a refining treatment for the oxide, fractional distillation might be employed successfully, but this has not yet reached the point of commercial application, although the field is quite encouraging. It has been thought that fractional condensation could be carried out in separat-



ing the oxide fumes as they come from the furnace. This has not been found feasible because the gases cannot be cooled uniformly, but even in spite of this some result might be obtained were it not for the formation of the antimonates of arsenic which are condensed with the antimony oxides and not at the lower temperatures of the arsenious oxides. This antimonate can be decomposed by heating to a high temperature so that the redistillation of the product would seem to be the more likely means of purification.

PRODUCTION OF ANTIMONY METAL FROM OXIDE

In order to reduce Sb_2O_3 to the metal, it would seem at the first glance that it would be only necessary to mix the oxide intimately with the right amount of carbon and heat it to the point of fusion. The difficulty, as far as this method is concerned, is that the antimony trioxide will volatilize before the temperature is reached at which the carbon will combine with the oxide. This can be overcome by adding to the oxide a fusible alkali to so lower the melting point of the mixture that fusion and reduction are effected before volatilization. When the product is in a state of fusion the reducing action of the carbon is very rapid. The amount of carbon required for reduction is that which is just sufficient to combine with the oxygen of the oxide to form carbon monoxide (CO) gas, for as soon as this gas is formed it leaves the furnace. The practice then is as follows: The metallic oxide is intimately mixed with 12 per cent of its weight of finely divided carbon and 6 per cent of sodium carbonate. The more intimately the mixing and the more finely divided the products, the more efficient will be the reaction. This mixture is spread over the floor of a reverberatory furnace and heated in a reducing atmosphere to temperature of from 800 to 900 deg. C.

The sodium carbonate combines with the antimony oxide forming sodium antimonate and carbon dioxide (CO_2). More antimony oxide is fused therein and the carbon then combines with the oxygen within the fusion forming CO and metallic antimony. This action continues until the reduction is complete, the metal being finally covered by a thin slag, composed of sodium antimonate and impurities. This slag will carry a larger percentage of metallic impurities than the original charge, but this refining action is of but a moderate character. The amount of loss in conversion will be, under good practice, from 10 per cent to 15 per cent of the metallic contents and a part of this will have been lost by volatilization in heating the charge. That portion which is lost by vaporization could be recovered by cooling the escaping gases and precipitating the fume. The percentage of alkali used as a flux has been determined empirically and is the minimum amount required to obtain the proper state of fusion.

It is desirable that a reducing atmosphere be maintained over the charge and that the heating be uniform. Under these conditions no rabbling is required.

The usual type of reducing furnace is a flat reverberatory furnace with a bottom sloping toward the tapping end. It has charging doors at both ends, but it is preferable to introduce the charge from a hopper feeding through the top of the furnace. It may be heated by either hot gas from a wood or coal fire or by means of oil burners, the latter being preferable.

The construction of a furnace with which the writer has had considerable experience is shown in Fig. 3.

After the reduction to metal in this furnace is complete, the metal is allowed to run from the tap hole into ladles and is poured into molds to form cakes of about 40 lb. weight. If as soon as the metal is poured, the

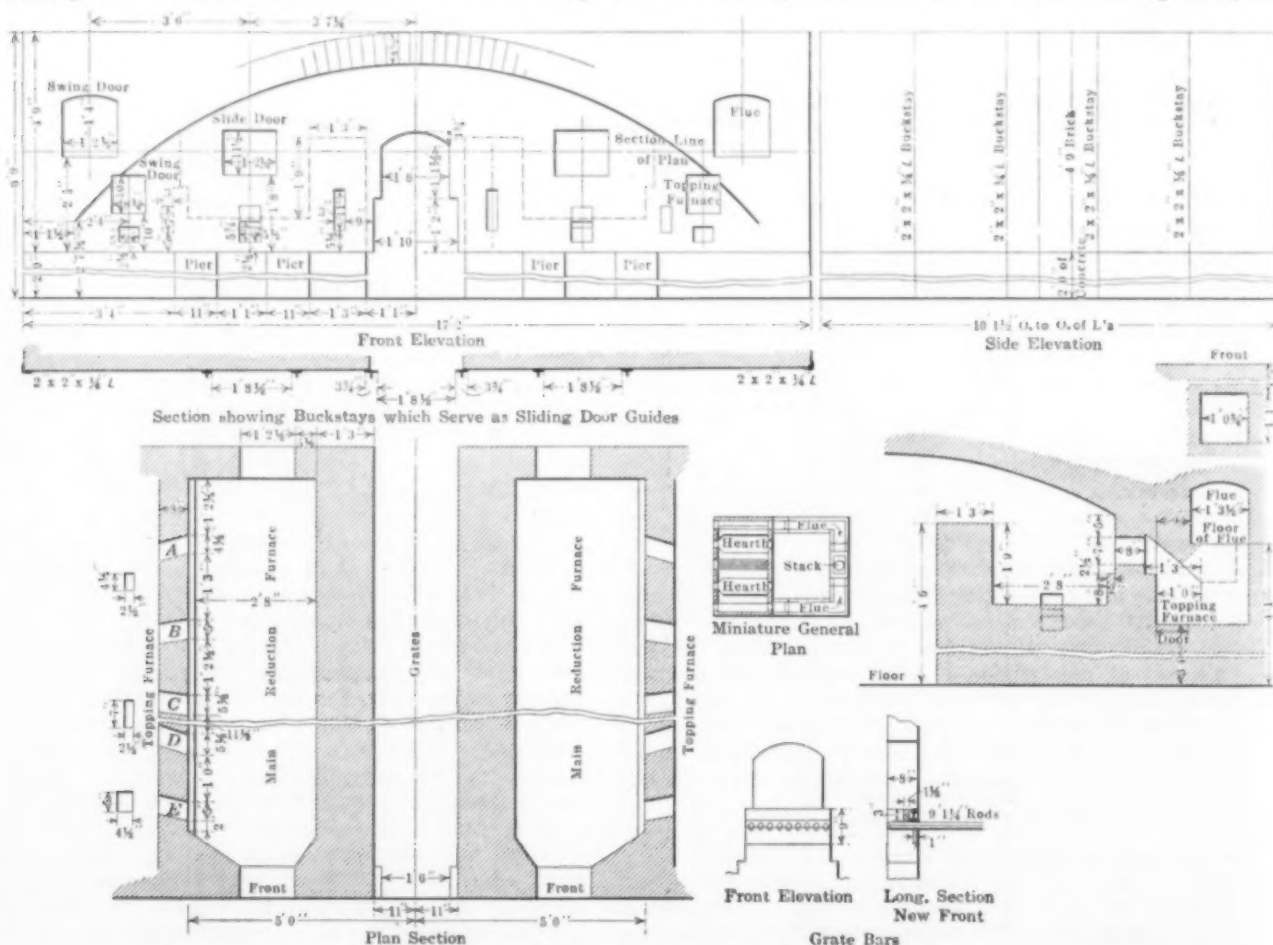


FIG. 3—PLAN AND ELEVATION OF REDUCTION FURNACE

surface of each cake is covered with fusible slag (generally made of sodium antimonate) oxidation of the surface will be prevented and the cake will cool more slowly. This slow cooling allows a beautiful starlike crystallization, similar in appearance to the frost patterns on a window pane, to form on the surface of the cake, and in the trade it is then known as star metal. This starlike crystallization is a special property of antimony and the starred surface has been taken as evidence of the purity of the metal. The presence of some metallic impurities might prevent this starring of the metallic surface, but it has been found that when arsenic alone is an impurity the crystallization is not altered in any way.

ARSENIC ANTIMONY ALLOYS

In fact, the properties of antimony and arsenic are so similar that, for many requirements, they serve practically the same purpose. Alloys of antimony and arsenic are more brittle than pure antimony, but when this metal is used as a hardening agent for other metals, the arsenic and antimony perform the same function.

The relationship between the boiling and melting points of the two metals is peculiar.

The melting point of crystalline arsenic under pressure is somewhat higher than that of antimony, the melting point of which is given by various authorities from 450 deg. C. to 632 deg. C., while similar references give the arsenic a melting point of from 500 deg. C. to 850 deg. C. When the boiling points are considered, however, it is found that crystalline arsenic sublimates at 554 deg. C. and antimony at 1440 deg. C.

If an alloy of these two metals is in a state of fusion and out of contact with air, it would be expected that the arsenic would distill off from the alloy and leave a pure metallic antimony. But as a method of purification this does not succeed, for when the arsenic is only present in quantities of from 2 to 3 per cent. then the pressure of diffusion will just about counteract the pressure of the arsenic vapor, and the distillation does not continue. This fact has been demonstrated by the author in a test where antimony metal containing a small amount of arsenic was heated in a reverberatory furnace at a temperature of about 900 deg. C. for eight to ten hours without reducing appreciably the percentage of arsenic.

Another interesting fact is that metallic antimony, although it will hardly oxidize at all when cold, will oxidize very rapidly when heated in contact with air to the point of fusion. If it should contain a small amount of arsenic, the antimony will be burned off under these conditions at about the same rate as that at which the arsenic will be distilled and oxidized. The antimony oxide fumes are poisonous, as are also those of arsenic, so it is possible that the difficulties of refining arsenical antimony may be to some extent alleviated in the future by developments in the use and application of the product.

In metal produced by the volatilization process, there can be but one impurity and that is arsenic, for the other metals found associated with antimony in its ores are not volatile. The entire refining problem, therefore, in dealing with antimony produced by this method is the disposal of this arsenic with its closely allied properties. The arsenic can be eliminated more easily from the oxide than from the metal, but it involves treatments which increase the cost of production and reduce the yield of product.

The amount of purification will, therefore, depend upon the amount of commercial discrimination against metal containing this particular impurity. It would appear that up to the present time the commercial valuations have been based more upon the analytical deter-

minations of impurities than the physical properties and structure of the metal itself and its value for specific properties.

As already pointed out, one of the chief uses for antimony trioxide is in the manufacture of white enamel. The tetroxide is not suitable for this purpose owing to its infusibility, so that it is necessary that the furnace control be such as to prevent the formation of this higher oxide. This commercial product is tested for its solubility in acids as a means of measuring its fusibility and freedom from tetroxide. The presence of small quantities of arsenious oxide in this material is apparently no detriment, and, in fact, it increases the fusibility of the product, making it easier to handle when the workmen have become accustomed to it.

The commercial opportunities in America for the application of the volatilizing process of antimony recovery are, therefore, quite promising, providing that a sufficient quantity of cheaply mined low-grade stibnite ore is available.

It would only be necessary to follow well defined scientific methods in roasting the ore and recovering the oxide so as to obtain efficient yields, and a stable industry could be established.

Grading of Crushed Stone and Gravel Feldspar, Fireworks and Flour

By Edward S. Wiard

CRUSHED STONE AND GRAVEL

The grading of crushed stone and gravel is an enormous industry. The value of crushed rock in 1914 was \$30,161,766, and the average price per ton was \$0.61. The rocks crushed are granite, which was sold at an average price in 1914 of \$0.76 per ton, having a total value of \$3,975,575. Trap rock sold at an average price of \$0.69 per ton and had a value of \$6,225,805. Limestone in 1914 was valued at \$18,061,881, and cost on an average \$0.55 per ton. Sandstone was valued at \$1,450,767, and had an average value of \$0.82 per ton in 1914. The uses to which the crushed rocks were put was in road making, the value of the total rock used for this purpose being 44.19 per cent, for railroad ballast 20.25 per cent and for concrete 35.56 per cent. In the more elaborate rock-crushing plants notable quantities of sharp sand are produced in the crushing processes, the value of which is included in the figures given under granite and sandstone.

The total value of the gravel produced in the United States in 1914 was \$9,398,897. Probably only a very small proportion of this was graded, though there are important centers where this is done. At Chicago, for example, the gravel grading business is an important

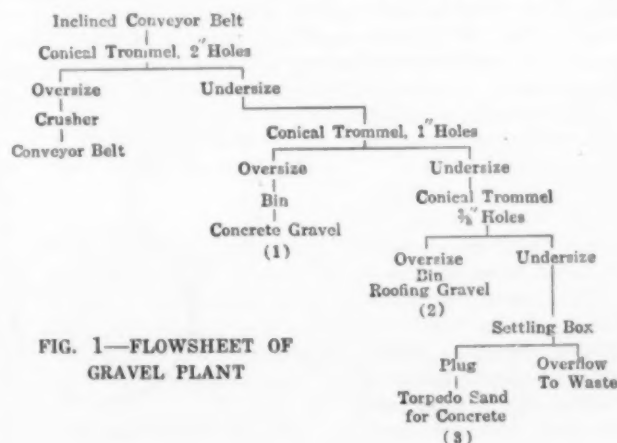


FIG. 1—FLOWSHEET OF GRAVEL PLANT

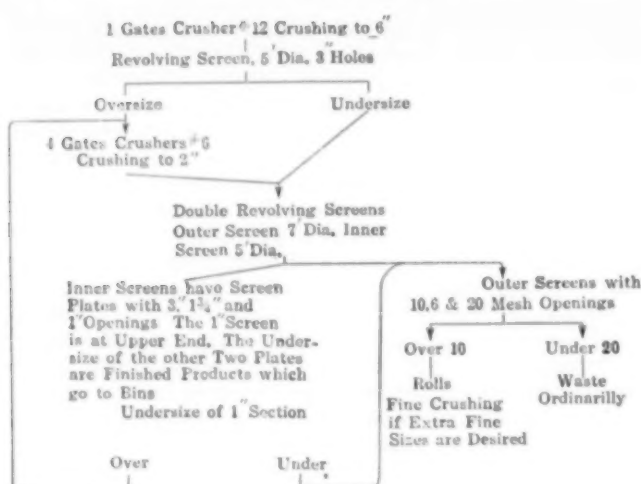


FIG. 2—FLOWSHEET OF ROCK CRUSHING PLANT

one and a plant capable of treating from 600 to 1000 tons per day is illustrated by its flowsheet in Fig. 1. The three principal products made, it will be noted, are large pieces of rock for concrete, a medium size for roofing and sand for concrete. The process is conducted with water. The gravel beds in the vicinity of Chicago are usually too wet to permit of dry screening, owing to the near presence of Lake Michigan.

The crushed stone industry has grown from an output amounting to about \$6,000,000 in 1900 to the large figure which has already been given. This growth has been due to the greater use of cement in concrete and the growth and improvement in public roads, due to the demand created by the automobile industry. The typical flowsheet of an Eastern rock-crushing plant of 3000-5000 tons daily capacity is shown in Fig. 2.

One of the problems of concrete making is the question of filling of voids. Experimental work undertaken at many places has shown that the amount of cement can largely be reduced by mixing with the rock and sand a certain proportion of very fine material without reducing the strength of the aggregate. Fig. 3 illustrates a more perfect theoretical mode of void filling. The three large spheres have a central void which can be filled, first with the largest sphere which can be placed in it. The remaining spaces can be filled with the largest spheres which they contain, etc. Eventually there will remain no voids.

In filling voids in this way with irregular fragments conditions would be obtained which would only approximate the arrangement shown in the diagram. With screens the filling of voids in the way indicated in the diagram would probably cause a great waste of material, since, as a glance at the diagram will show, the jump from the largest size to the next lowest is very great. The McKesson machine may, however, offer means of selecting numbers of sizes which can be grouped for a very close filling of the void. The bond in all void-filling problems is the most expensive material to use.

A further difficulty which would ensue on attempting to realize the arrangement shown in the diagram or something similar with irregular shaped grains would be the difficulty of making the grains take the most compact posi-

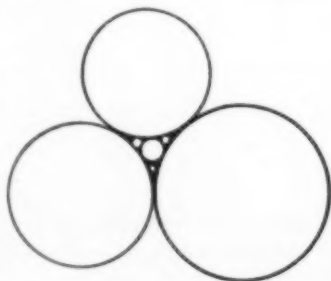


FIG. 3—FILLING VOIDS

tion. The more thorough the mixing, which should be of such a character that the component parts of the aggregate will not tend to separate into layers according to gravity or size, the more nearly the aggregate would attain a symmetry similar to the one shown by the figure.

FELDSPAR

This material is used for making pottery, enamel ware, enamel brick, electrical wares, and as a constituent part of both body and glaze in true porcelain, white ware, vitrified sanitary ware, and in underglaze and glaze in so-called porcelain sanitary wares and enameled brick. For pottery purposes the feldspar must be free from iron-bearing minerals, biotite, garnet, hornblende, etc., and have little or no mica. For the finer grades of pottery the quartz limit is about 5 per cent. For ordinary pottery the quartz may run as high as 15 to 20 per cent. The use of feldspar in emery wheels has been mentioned. A small amount of very pure feldspar is used in opalescent glass. Extra select feldspar is used in the manufacture of false teeth. Some is used for scouring soaps, and has the good quality of being slightly less hard than glass. It thus will not scratch glassware, and this kind of soap is valuable for cleaning windows.

The raw feldspar from the quarry is fed to a buhr mill, the stone being from 3 to 5 ft. in diameter and 1 to 1 1/2 ft. thick. The spar is crushed between the stone and the bed. Following the mill crushing the spar is screened, the oversize returning to the mill and the undersize passing to tube mills. The buhr mill consequently works in a closed circuit.

For pottery purposes the spar is usually ground from 4 to 6 hr., when nearly all will pass a 200-mesh screen (96 to 98 per cent). What is called No. 3 spar is not ground so fine, only about 75 per cent of this grade will pass a 200-mesh screen. This grade of spar remains in the mill but two or three hours. For abrasive soap the spar is ground 10 hr.

Just as with cement there is a problem awaiting solution and this problem has to do with the advisability of making a closed circuit with the tube milling.

A wet process for separating the very fine spar would increase the cost of production, as it would be necessary to disintegrate the dry caked spar, and this method is used only in a few mills.

An effective air separation might be employed where an extra-fine grade of high-grade spar was wanted, but it does not seem to have been employed at any of the mills.

The chief sources of feldspar lie in the states of Connecticut, Maine and a portion of Pennsylvania, Delaware and Maryland. The best grades are sold as high as \$5 or \$6 per ton in the crude condition and over \$10 ground. Excellent feldspar also comes from Canada. The production of domestic spar was 135,419 tons in 1914 and valued at \$629,873. The production of crude spar was 85,905 tons, valued at \$263,476. The production of ground spar was 49,514 tons, valued at \$366,397.

FIREWORKS

In making the stars for roman candles and other fireworks brass screens are used to separate the sizes made, usually six in number.

FLOUR

The cleaning and grading of wheat will be discussed in a later article. The old mode of producing flour was by the use of mill stones, the aim of the miller being to get as large a bulk of floury material as possible at one operation. The result of this was that the flour con-

tained much worthless material, lacking in nourishment, harmful, such as germs and crease dirt.

The various breaking and screening operations which take place in a modern flour mill are of very great complexity, every mill being different in the types and mode of arrangement of machines employed.

In the large mills the flowsheets or diagrams showing the position and type of machines used are very jealously guarded.

Wheat is a fruit and not a seed as is most commonly thought. A magnified section of a portion of wheat berry is shown in Fig. 4. The outer part marked *B* is considered to consist of four more or less branny coats, the inner one of which has some food value; but owing to its color it is eliminated as far as possible from domestic brands of flour. The interior part *C* forms the bulk of the household flour. *D* is the germ or true seed. This is a tough, oily body which if not removed becomes rancid and interferes with the keeping quality of the flour.

In breaking by rolls the germ is flattened and easily removed by a later screening operation. The placenta is a cord passing upward between the outer coats, its function being to furnish a passage through which liquid nourishment may enter the berry during the stage of growth. The placenta acts as a filter, removing im-



FIG. 4—SECTION OF THE LOWER PORTION OF A WHEAT BERRY MAGNIFIED

purities from the sap. The impurity which thus collects is called crease dirt and will discolor the flour if not removed.

It will now be understood why a simple grinding process, followed by screening, will not yield the best results in flour making. A further reason lies in the varying demand of the trade. Household flour must be very fine and white, while bakers' flour must be strong, quick-rising, and hence contain a large proportion of gluten. The glutenous material, as the diagram shows, lies outside the starchy white center.

To obtain the highest grade of domestic or household flour the mode of procedure would be as follows: The prepared and cleaned wheat berry passes to the No. 1 break rolls, where after screening in a screen with gentle action such as a gyratory bolter would yield some flour of a coarse size containing bran adhering to the interior portion of the berry and suitable for further rolling. Some true middlings would also be formed contaminated with some loose and adhering bran. Middlings resemble the familiar breakfast food "Cream of Wheat" and are largely granules of the interior white starchy part of the grain. These middlings are then sent to a purifier, which is a screen with an air current passing through it to carry away the light loose bran. The purifier would at the same time yield two sizes of middlings and a very branny product. On again rolling the coarser part of the middlings, and

screening in a screen with a strong action such as a centrifugal reel, a very high grade domestic flour is obtained containing a minimum of branny impurity and a fair amount of gluten.

The flour from the first break and first screening yields a cheap, good, strong bakers' flour after a number of other operations. An outline of the beginnings of an elaborate flowsheet has been given, and it would be impossible within the limits of articles such as these to carry the flowsheet further to the production of other grades of flour and by-products.

The various types of screen have been touched upon. Two of the chief events in the mechanics of flour milling were the introduction of rolls about 1850. The invention seems to have been Hungarian, and mills employing rolls formerly denominated their process by Hungrainia or Hungarian Patent Processes, etc.

The other great advance came with the introduction of the purifier, the invention of which in 1859 is ascribed to Lacroix, although others almost simultaneously developed inventions along similar lines. These innovations gave a greatly increased yield of salable flour.

Gyrating bolters are used where a gentle action is desired as well as plain reels. For strong action centrifugal reels are employed, particularly where quantity rather than quality is desired, as the strong action of the centrifugal machines will force much material through the apertures, which would not be desirable for a high-grade product. Centrifugal reels are adapted to bolting soft, fluffy material, dusting bran, etc.

Silk cloth and grit gauze are used exclusively in flour milling owing to their freedom from contamination, the ease with which they yield when brushed or rubbed to free the apertures from blinding. In this connection it should be noted that owing to the nature of floury products screening is largely accomplished by a process of blinding and rubbing through the apertures. Another good quality of silk cloth is that it will not wear smooth, but exerts on the products a gentle friction tending to liberate flour or other finished products.

The function of a middlings purifier has been touched upon. This is merely a flat shaking screen housed with means for carrying up through the mass on the screen air currents, thus bringing the light material to the top where some of it is carried off to a dust collector and the balance discharged from them. While the light stock is being held up in this way, chance is given in the bed of material below for the screening out of different size products; the material discharging at the end contains mainly impurities. Means are also provided for keeping the screen from blinding.

There is one grading problem in the mills which is not regarded as of much moment by practical flour millers, and that is the grading of the wheat before rolling. The rolls are all set with faces at fixed spaces apart; consequently, with some variation in the size of the berry some are more severely broken up than others. The Rich grader has been proposed for this service and a description of this machine will be found under the head of malt. It has no application in the flour mills. The McKesson machine may have a similar application in an improved form.

Industrial Exposition at Springfield.—The Industrial Exposition and Export Conference which was originally to have been held May 26 to June 2, at Springfield, Mass., has been postponed to June 23-30, to meet the wishes of a number of manufacturers who desired to have the later date. Mr. F. H. Page, president of the National Equipment Company, is chairman of a general committee.

Recent Metallurgical and Chemical Patents

Electric Furnaces

Continuous Induction Furnace.—An electrical induction furnace for melting metals, and for smelting iron and other ores, is patented by PARVIN WRIGHT, of Vancouver, B. C. In smelting work the charge is fed continuously into smelting furnaces adjacent a crucible. The different smelting furnaces overflow into the same crucible and the molten metal is withdrawn continuously from the crucible. The furnaces and crucible are heated by induction. It is claimed that the continuous operation of the furnace gives a constant consumption of current in the furnace and maintains a constant load on the generator. (1,218,151, March 6, 1917.)

Electric Steel Furnace Regulation.—A method of regulating the positions of the electrodes in an arc furnace, either automatically or by hand is patented by JOSEPH L. DIXON of Detroit, Mich. In arc furnaces where two-phase current is supplied through four movable electrodes it is desirable to preserve uniform heating conditions by keeping the lengths of the four arcs formed under the electrodes as nearly equal as possible. In such an arrangement each pair of electrodes belongs virtually to an independent single phase circuit, since all the current passing through either member of either pair finds its way back through the other member of the same pair. In consequence, an indicator of changes in current strength associated with either or both members of a pair would not alone give a significant indication, since any change of current shown is due to a change in the sum of the lengths of the pair of arcs and not to any change in either arc alone. Such a system must therefore be furnished with both ammeter and voltmeter apparatus, whether for hand or automatic regulation. This greatly complicates the problem of regulation and makes proper efficient handling quite difficult. The present patent proposes to avoid these objections by supplying two-phase current from two transformers having divided secondaries, and so connecting the eight secondary terminals among themselves that the resulting vector diagram becomes a square, which may be considered as a special case analogous to a delta connection. The four movable electrodes are then connected so that they appear at the four corners of the square in the vector diagram. By employing the arrangement described, the current leaving any one of the four electrodes does not return exclusively through any single electrode. Consequently, if any of the four approaches the bath too closely or does not approach it closely enough, a single ammeter related exclusively to the supply conductor of that electrode will indicate an increase or decrease of current betraying the existing difficulty. Such an ammeter can then either serve to guide hand control or to govern automatic control in any well-known manner, without the necessity of using voltmeters. (1,214,763, Feb. 6, 1917.)

Heat Treating Furnace.—FRANK T. COPE of Alliance, Ohio, patents an electric furnace in which the trough containing the resistor material is located in the heating chamber of the furnace and is constructed with air spaces around it for air circulation. The patent is assigned to the Electric Furnace Company, of Alliance, Ohio. A longitudinal sectional view of the furnace is shown in Fig. 1. The base of the furnace 1 is of metal and the hearth 3, side walls and end walls are made of fire brick. The refractory trough 8 contains the granular refractory, resistance material 9, and electrodes 10 embedded near each end of the trough. The refractory trough is supported upon a series of transverse supporting walls 11, and the trough is spaced away from the side walls and roof so as to allow the air to circulate

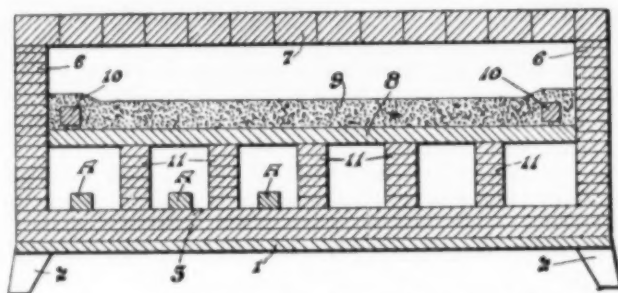


FIG. 1—LONGITUDINAL SECTION OF FURNACE

around the trough, preventing excessive heating of the trough upon any one side and causing a more even temperature. The billets to be heated are shown at A. (1,218,058, March 6, 1917.)

In another patent of THADDEUS F. BAILY and FRANK T. COPE a terminal is described which is designed to prevent the electrode from oxidizing at the point where it enters the furnace. This is accomplished by enclosing the electrode in a sheet metal box and filling in the space with flake graphite, carborundum or charcoal so that it completely surrounds the electrode. The outer extremity of the box is supported and insulated from the furnace by means of a block of fire clay supported by brackets from below, and by fireclay joints. Electrical connection from the electrodes to the cables is made by laminated copper strips. The granular material will be gradually oxidized and can be renewed from time to time. (1,218,042, March 6, 1917.)

Iron and Steel

"Combined Acid and Basic" Steel Process.—A process of making steel from relatively cheap materials is patented by GEORGE G. MCMURTRY of New York City (Patent assigned to U. S. Steel Corporation). The basic and acid processes are combined and a neutral furnace lining of zirconia is used. The process may be carried out in either an open hearth or electric furnace. The procedure for an openhearth furnace is given as follows: "Pig iron and scrap with limestone and iron ore form the charge. The lime and ore form a slag which oxidizes and eliminates from the bath phosphorus, silicon, manganese, carbon, etc. This slag is removed from the metal, either by scraping off the slag or by tilting the furnace and allowing it to flow away, or by removing the molten metal from the furnace and replacing it in the furnace minus the slag covering. A second slag, acid in character, is then added consisting, for instance, of silica sand, and the operation finished in the usual manner of working the acid open hearth process.

In an electric furnace the procedure is given as follows: "I place in an electric furnace, which is lined with a neutral refractory material, such as zirconia, the metal to be treated. I provide a slag, consisting of lime and iron ore, by which various metalloids are eliminated. I then remove the slag in one of the ways mentioned in connection with the open hearth procedure. I then add a slag very basic in character, consisting usually of lime and fluorspar, but which may also contain a certain amount of silica. By means of a reducing agent, such as carbon, silicon, aluminium, etc., I reduce oxides from the slag and, at the same time, remove sulphur from the metallic bath, by treating it in the slag as calcium sulphide. The slag extracts a certain amount of sulphur from the bath, which forms calcium sulphide and which tends to return very readily into the bath. The powdered carbon or similar reducing agent thrown on the slag combines with the sulphur of the calcium sulphide therein and prevents its return to the bath.

There is thus a continued extraction of sulphur from the bath, without the usual returning of the same, and consequently a desulphurization of the bath. I then remove this basic slag from the bath of molten metal and thus get rid of the sulphur, leaving in the bath any metals which may have been reduced from their oxides. I then add an acid slag, consisting for instance of silica sand, and proceed in the usual way to finish the refining according to the acid process, except that in this case the heat necessary is obtained from the electric arc instead of by the combustion of gases in the melting chamber of an open-hearth furnace." (1,217,972, March 6, 1917.)

Regenerative Annealing Furnace.—An annealing furnace with regenerative chambers and for use with either gas or oil fuel is patented by ARTHUR L. STEVENS of Chicago, Ill. The furnace is made of the usual brick work walls and roof and reinforced by a structural frame. It is built upon a concrete foundation, and the front end of the furnace contains a door which can be raised to admit a truck which runs upon rails and which has a fire-brick platform. On this truck the material to be heated is placed. The truck and its load are borne by the foundation, the furnace structure not being subject to any stress. Arches are eliminated except for the roof. The whole furnace including the regenerator is above ground. The combustion chambers are on the sides of the furnace between an outside and inside wall, and the material is heated mostly by radiation, no flame coming in direct contact with it. The regenerative chambers are at the ends of the furnace. (1,219,499, March 20, 1917.)

Oxygen and Hydrogen

Electrolytic Oxygen and Hydrogen Cell.—A diaphragm cell for the production of oxygen and hydrogen is patented by R. J. J. MUELLER of Chicago, Ill., and E. G. ROWLANDS, of Milwaukee, Wis. The patent is assigned to the Universal Oxygen Company, a Wisconsin corporation. The casing of the cell is made of cast iron which also acts as a cathode together with other cathodes consisting of a number of cast iron plates suspended in the cell and parallel to the sides. The casing is open at the top and is provided with a cover which is insulated from the tank, and contains the terminals of the anodes. The anodes are tubular, closed except at the top and bottom. This structure is claimed to produce an automatic circulation. The cathode plates and tubular anodes do not extend to the bottom of the cell, but leave a clear space. The bottom of the cell is coated with paraffin and a glass plate laid upon it. This is to prevent the current from going from the anode to the bottom of the cell and thus generating hydrogen which would pass through the bottom of the diaphragm into the oxygen space above. The diaphragm is made of non-metallic woven fabric such as felt or asbestos treated with paraffin. A diaphragm encloses each positive electrode, but is open at the bottom to allow of solution circulation, but the bottom of the diaphragm is lower than either electrode. (1,219,843, March 20, 1917.)

Generation of Oxygen.—A method of generating pure oxygen for use in such places as on submarine boats is patented by JOHN F. SANDERS, of Roseburg, Oregon. The patent is assigned to O. P. Coshov of Roseburg, Oregon. In order to prevent contamination of the oxygen with hydrogen, which is dangerous, use is made of an electrode which absorbs hydrogen. A compound cathode consisting of palladium sponge or palladium black with some rhodium, is stated to absorb the most hydrogen. Rhodium is stated to be more important as a catalyst than as an absorber of hydrogen. When the cathode has become saturated with hydrogen

it is submerged in ammonium persulphate and is restored again to its absorbing condition. The rhodium acts as a catalyst to combine the hydrogen of the cathode with the oxygen of the persulphate. The same kind of plate is used for the anode as for the cathode. Pure water is used for the electrolyte. (1,218,584, March 6, 1917.)

Potash

Potash from Feldspar.—Henry Blumenber of Los Angeles, Cal., patents a process of rendering soluble the potash in orthoclase by heating with sodium nitrate. Orthoclase, pulverized to pass 200 mesh and sodium nitrate of the same fineness are mixed in equal proportions and heated in a closed cast iron crucible to 1200-1500 deg. Fahr., until completely fused. The nitric oxide fumes are withdrawn at the top and used for making nitric acid or are absorbed in lime to form calcium nitrate. The heating is stopped when no more nitric oxides come off, usually requiring about thirty minutes. The end product in the crucible is a sodium potassium aluminium silicate which is withdrawn through a valve at the bottom. This is pulverized after solidification and will contain about 7 to 10 per cent water soluble K₂O. It may be used as such or concentrated further by extracting the sodium, potassium and aluminium with sulphuric acid. (1,214,003, Jan. 30, 1917.)

Synopsis of Recent Metallurgical and Chemical Literature

Calibration of Viscometers.—The Bureau of Standards has conducted considerable work on the subject of viscosity and has just published Scientific Paper No. 298, entitled "Standard Substances for the Calibration of Viscometers," by EUGENE C. BINGHAM and RICHARD F. JACKSON. The measurement of the viscosity of a liquid is frequently an indication of its quality. For example, many grades of oils are tested and classified according to their viscosities. The viscometers used in performing these tests are constructed in a great variety of ways and yield very different results unless controlled by liquids of accurately known viscosities. The standards proposed are pure water, mixtures of alcohol and water, and solutions of sugar in water. All previous measurements of water and of alcohol and water were carefully recalculated by the authors and the viscosities of sugar solutions were measured for three different strengths at temperatures between 0 and 100 deg. C.

The following summary of the work is given by the authors:

"For the purpose of the calibration of viscometers, there is need for one or more liquids whose viscosity is greater than that of water, which can be easily obtained, and whose viscosity is known with a considerable degree of certainty.

"Of the suitable substances ethyl alcohol-water mixtures and sucrose solutions each possess certain marked advantages. The viscosities of the former are well known, there existing data by several observers which agree as well as can be expected; but the correctness of the data for the latter has been questioned. Hence we have redetermined the viscosity of a 20 and a 40 per cent solution by weight and have in addition measured the viscosity of a 60 per cent solution from 10 deg. to 95 deg. C. The viscosities obtained by us are generally somewhat higher than the values obtained hitherto, but we have every reason to believe that our values are worthy of confidence.

"The existing data on the viscosity of water have been reviewed in order to correct it so far as possible

according to our present knowledge. The viscosity and fluidity of water for every degree Centigrade from 0 to 100 has been calculated.

"The advantages and disadvantages of expressing viscosity in absolute or specific units have been compared. The suggestion has been made that by expressing all data in terms of the centipoise (the one-hundredth part of the cgs unit), the absolute viscosity of substances would be practically also the specific viscosity, provided that we take water at 20 deg. as the standard. We find the most probable value for the viscosity of water at 20 deg. C. to be 1.005 cp."

Steel Industry in Germany.—The report of the German Steel Union for the year ending June 30, 1916, contains interesting data showing the ratio of various products made during the second year of the war. The following data from the report are taken from *Engineering* (London):

"In what may be called peace commodities, railway material and sections, there was a further retrogression in manufacture, whilst in the half-finished products wanted for war material there was an increase of 18 per cent. The quantities of half-finished products dispatched during the year amounted to 64.12 per cent of the allotment, against 54.14 per cent for the preceding year. On the other hand, the figures for railway material receded from 68.41 per cent for 1914-15 to 61.88 per cent for 1915-16, and those for sections from 35.48 per cent to 32.31 per cent. The prices during the year under review had been materially raised owing to increase in cost of manufacture and to the position of the market, the advance during the year amounting from 15 to 17.50 marks per ton for the different goods. Export prices had also been much higher, but in the interest of the army requirements exports had been much reduced and had been subject to special control. In the former, normal times about one-third to four-fifths of the output of half-finished products and railway material were exported. The export of half-finished products during 1915-16 receded to 9.66 per cent, against 23.80 per cent for the previous year. For railway material and sections the figures were respectively 11.28 and 15.64 per cent and 20.81 and 21.11 per cent. The exports of the different commodities, in percentages of the total quantities for the last eight years, were:

Year	Half-Finished Products, Per Cent	Railway Material, Per Cent	Sections, Per Cent
1908-9	36.27	28.25	22.47
1909-10	34.00	34.47	33.45
1910-11	36.92	44.08	25.64
1911-12	39.69	37.19	25.61
1912-13	38.14	33.97	27.93
1913-14	45.87	31.64	24.93
1914-15	23.80	15.64	21.11
1915-16	9.66	11.28	20.81

"As regards railway material the home contracts, in spite of some supplementary orders from the Prussian and the Imperial State railways, showed a decrease, as far as these railways were concerned, whilst the other German State railways, partly at least, placed higher orders than during the preceding year. A fresh three years' contract was concluded with the Prussian State railways last June (for the year 1917-1919) on the basis of 129 marks (£6 9s.) per ton for rails. The business in rails for mining purposes had been satisfactory. As far as the foreign trade was concerned some satisfactory contracts in heavy railway materials were secured from neutral States and the Balkans, both as regards quantities and price. As the building industry remained generally almost at a standstill, the demand for sections naturally was affected, but there was a fair demand from railway carriage manufacturers and from engineering shops. From abroad the demand was very

quiet during the first half of the year, but in January it began to increase, and became active. Regard for the home market, however, coupled with the impossibility of giving prompt delivery, impeded the trade. The business expenses during the year to be defrayed by the combine amounted to 1,835,593 marks, against 1,649,746 marks for the preceding year."

Survey of California Oil Fields.—The first annual report of the State Oil and Gas Supervisor of California has recently been issued. It covers the last half of 1915 and the first half of 1916. The law establishing the Department of Petroleum and Gas of the State Mining Bureau became effective Aug. 9, 1915. The department is under the general jurisdiction of the State Mineralogist, who is authorized to appoint a supervisor to supervise the drilling, operation, maintenance and abandonment of petroleum or gas wells, in order to prevent damages from infiltrating water and other causes. This report covers the first year's operations of this supervisor and his assistants, and shows that most successful work was accomplished. The following paragraph from the report explains the conditions as the bureau found them:

"The work of the bureau during the past year has not been directed to a study of operating conditions, but observation of them could not well escape notice while the regular work was being carried on. In fact, a most excellent opportunity has been afforded to compare various methods. This broad field of observation justifies the statement that *there is probably no large business so inefficiently conducted as is that involved in the production of oil in California*, notwithstanding the fact that mechanical operations here seem to be more advanced and improved than in any other part of the world. The annual losses, due to unsystematic work and actually paid out of pocket, amount to hundreds of thousands of dollars. Bankruptcy would speedily follow such management in any line of business, not dependent upon either a most abundant natural supply of crude material or fresh infusions of capital from other sources. These two alleviating conditions cannot be expected to continue indefinitely."

The extent of the oil industry in California is given roughly as follows: There are 80,702 acres of proved oil land, with a market value of at least \$1,000 per acre, or a total of \$80,702,000. There are approximately 2000 miles of pipe lines costing on an average of \$20,000 per mile, or a total of \$40,000,000. There are nearly 30 refineries, with a total daily refining capacity of about 175,000 barrels of crude oil and representing a total investment of probably \$15,000,000. There are approximately 40 tank steamers serving the California oil fields, having a total carrying capacity of about 1,500,000 barrels and costing not less than \$15,000,000. The producing oil wells number over 7000 and have cost over \$100,000,000. Therefore the total investment in the oil business, without considering such railroads, towns, electric lines, water systems and other improvements constructed solely on account of it, represent an expenditure of at least \$250,000,000. There is a constant annual addition to these expenditures due to the drilling of new wells, which during the past fiscal year amounted to about \$6,000,000 for 400 wells. Annual expense also involves deepening, redrilling and abandoning wells, which during the past year probably cost nearly \$1,000,000. The work of the State Mining Bureau in protecting the oil fields against infiltrating water depends upon full and complete logs of wells and the law requires that they be furnished the bureau. Where poor records were encountered it was usually found that the operator had not kept daily reports. A short description of the method of extracting gasoline

from natural gas by absorption in oil is given, and it is stated to be worthy of the attention of California operators. A full description of this method was given in this journal June 1, 1916, page 651-60. Gasoline is extracted from natural gas at present in California mostly by the use of compressors.

Industrial Gas Burning.—A method of making a gas burner which is stated to give complete combustion of the gas is described by F. S. SINNATT in the Journal of the Municipal School of Technology (England) Vol. 8. It is extremely desirable that no carbon monoxide be left unburned. This is accomplished in the ordinary domestic burner by admitting more air than is required



FIG. 1—BRAZING BURNER

to oxidize the gas. The addition of an excess of air, however, leads to two sources of waste, first a lowering of the flame temperature, and second, an increase in the heat units carried away in the waste products. Many of the objectionable features of gas as a means of heating metal or other cold surfaces are overcome to a degree by mixing the gas with air under slight pressure previous to its arrival at the point of combustion. This yields a form of blow-pipe flame, and it is possible by this method to add to the gas the exact volume of air required for complete oxidation. Back explosion must be prevented, and this is done by burning the mixture on a thick gauze or perforated plate, and by increasing the velocity of the gas. A combination of these two processes comprises the author's method. He overcomes many of the difficulties of burning gas completely in this manner by making the perforated plate or gauze concave on the side upon which the gas is burning. The perforations should have a common focus. The whole of the flames burning on each of the separate perforations are thus made to pass through a common point, or the flames are focused. The effect of this treatment is to overcome within wide limits any variations in the composition of or the pressure of the gas. It is nearly impossible for the gas to escape combustion owing to it having to pass through the common focus. The combustion of the gas is in a degree self-induced, and the rate at which the gas burns



FIG. 2—METAL BURNER

on the plate is increased by the thorough mixing which occurs. Differences in the size of the perforations cannot influence the flame to the extent they do on a flat perforated plate. The degree of concavity required for different pressures and for fuel gases of different compositions was determined experimentally for the gases which have been burned by the system. The size of the perforations and the thickness of the metal of the plate are factors which influence the concavity necessary for any particular gas. At present the method adopted, practically, is to use small disks about half an inch in diameter and to fit these into any type

of burner, the number of the disks being varied according to the volume of gas to be consumed. Fig. 1 shows a brazing burner and Fig. 2 a metal melting burner.

Hydroelectric Exhibit of Canadian Pacific Railway

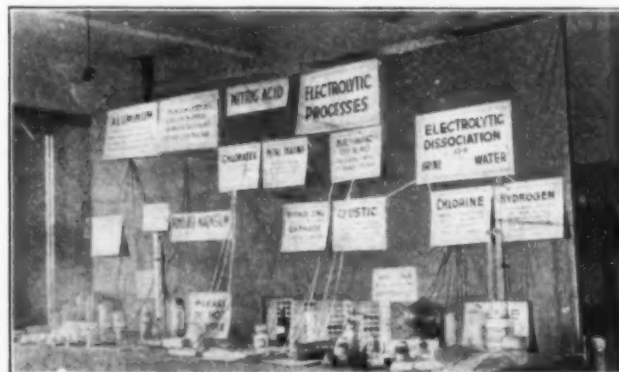
An interesting electrical and electrochemical exhibition was held at Montreal, Canada, from March 12 to 31, by the Canadian Pacific Railway. The exhibit was arranged by the Natural Resources Survey of the Railway of which Arthur D. Little, Ltd., are directors, and was held in the latter's industrial museum at 137 McGill Street.

The object of the exhibit was to indicate the large amount of waterpower available for development in Canada and to show the various electrochemical products which can be produced, and which have been produced from the electric current generated at Niagara Falls and other points in the United States and Canada.

Attention was called particularly to the importance of the electrochemical and electrometallurgical products to our industrial life. Practically all of the important products were shown, including ferroalloys, calcium carbide, cyanamide, caustic soda, chlorine, bleach, oxygen, graphite, electric steel, etc. Around each primary product the related products were grouped into whose manufacture the primary product entered, for instance, acetylene made from calcium carbide and cyanide made from metallic sodium. In this way the importance of the electrochemical products was brought out. Electric lighting was also represented by an exhibit of various kinds of lamps.

It was shown that the water powers of Canada at present commercially available are widely distributed. A map showing those over 5000 hp. and adjacent the Canadian Pacific line had been prepared. More than ninety separate waterpowers are shown on this map aggregating about 7,500,000 hp. Of this amount about 750,000 hp. or 10 per cent has been developed.

Many industrial concerns from the United States and Canada loaned products and specimens. Among these companies were the following: Acheson Graphite Company, American Cyanamid Company, Henry Birks & Sons, Ltd., Canadian Aeroplanes, Ltd., Canadian Car & Foundry Company, Ltd., Canadian Electro Products, Ltd., Canadian General Electric Company, Ltd., Canadian Pacific Railway Company, Angus Shops, Canadian Salt Company, Chemical Products Company, East End Garage, Electric Reduction Company, Foote Mineral Company, Hamilton & Hansell, Halcomb Steel Company, Harbison-Walker Refractories Company, Lyman, Ltd., D. W. Massie of Munderloh & Co., Ltd., Mc-



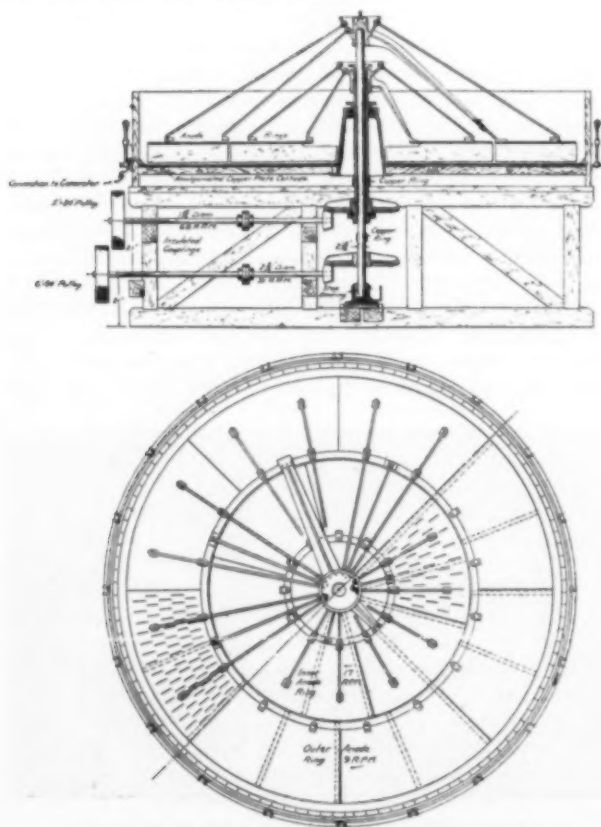
PART OF CANADIAN PACIFIC RAILWAY ELECTRO-CHEMICAL EXHIBIT

Gill University, Department of Chemistry, Montreal Light, Heat & Power Company, Montreal Water & Power Company, Mount Union Refractories Company, Nitrogen Products Company, Northern Aluminum Company, Norton Company, Norton Laboratories, James Robertson & Company, Ltd., Schoellkopf Aniline & Chemical Works, Inc., Shawinigan Electro Metals, Ltd., Snyder Electric Furnace Company, Standard Alloys Company, Fred Thompson Company, Ltd., Titanium Alloy Manufacturing Company, Tivani Electric Steel Company, Watson Jack & Company, Ltd.

New Electrocyanide Process

A new electrocyanide process which is claimed to amalgamate the gold values in the ore directly from the cyanide solution and to regenerate the cyanide has been developed by Messrs. Sill & Sill, mining and metallurgical engineers of Los Angeles, Cal. The apparatus used is the electrocyanide pan, in which the pulp is thoroughly agitated and aerated in cyanide solution and simultaneously subjected to the action of an electric current, whereby a rapid dissolution and a cathodic amalgamation of the precious metals in the ore is secured.

The pan is 15 ft. in diameter and 30 in. deep. Through the center of this pan a small casting projects which permits the passing of the working shafts. The bottom of the pan is practically completely covered by an amalgamated copper plate, to which mercury is added automatically in the course of operation. About 5 in. above the copper or cathode plate is suspended a cast-iron plate equal in area to the copper plate. This cast-iron plate is divided into two annular rings, the outer one having 60 and the inner one 40 per cent of the anode area. On the lower side of each anode ring wooden paddles are fastened radially, about 5 ft. apart, the bottom of the paddles being a couple of inches above the amalgamated copper cathode.



FIGS. 1 AND 2—THE ELECTROCYANIDE PAN

These annular anodes are revolved in the same direction and independently by means of pulleys, gears and a solid and hollow shaft so that any midway point of the inner ring travels practically the same number of feet per minute as the corresponding point on the outer ring. The motion imparted to the pulp by the annular rings and the paddles is a compound rotary one, which causes the pulp confined between the anode and the cathode to circulate in a uniform spiral movement in an outward direction. The ore is thus kept in a perfect state of suspension.

The centrifugal force imparted by the paddles causes the pulp, on reaching the outer edge, to rise between said edge and the outer edge of the outer anode to a height of approximately 16 in., retaining the rotary motion imparted by the paddles and endeavoring by gravity to seek the lower level at the center of the pan. The resultant motion is in a downward and inward spiral until it passes over the inner edge of the inner anode near the center cone, where it again meets the paddles and the cycle continues.

The air required for aeration of the pulp is supplied at the periphery of the pan and on a level with the copper cathode by means of twenty jets uniformly distributed. Figs. 1 and 2 show sections of the electrocyanide pan.

The capacity of the pan depends entirely on the character of the ore treated. With the exception of clayey ores the dilution for the ores is one to one. The pan charge under normal conditions is 7.5 tons of dry ore by weight. If the dilution is one to one and one-half, the charge is 6 tons. The time required varies between one to twelve hours, but generally the operation may be completed in two and one-half hours. Considering the factors mentioned, the maximum capacity varies from 15 to 90 tons per day. On the average run of ores, however, the capacity is from 36 to 60 tons per day.

The electrochemical part of the process is stated to be as follows: In treating a 7.5-ton pan charge holding the same weight of water with the requisite amounts of lime and cyanide, finely crushed salt is added until the ammeter reads 300 to 400 amperes with a voltage of 9.5 to 10 volts. The sodium ions are precipitated on the amalgamated cathode and caustic soda is formed. This then combines with the acid radicals in the electrolyte and thus protects the cyanide from compounds which the lime does not readily neutralize very effectively.

Very little mercury is lost during the process. If there is some mercury in the electrolyte it readily yields to the combined electrolytic and cyaniding action, whereby it is electrochemically precipitated onto the cathode.

An average sized pan will have its power distributed as follows: The total power required for a single pan is from 6.1 to 8.1 hp., of which 0.6 hp. is for mechanical agitation, 1 to 1½ hp. is for compressed air and 4½ to 6 hp. is for the electrolytic process. The compressed air for aeration is used at 100 lb. pressure.

It is claimed for the process that it will treat successfully heavy manganese ores, lead, zinc and copper carbonates carrying gold and silver, pyritic gold ores and arsenical pyrite carrying gold and silver.

Among the advantages claimed for the process are the elimination of filtering devices and of zinc precipitation, making the handling of very clayey ores possible.

Celluloid Making in Japan was very little profitable until 1914, but at present the only manufacturer is extremely busy. He exports to England, France, Russia, America, Australia, China, etc. The value of celluloid articles made in 1914 was \$1,500,000.

Book Reviews

Elements in Mineralogy, Crystallography and Blow-pipe Analysis. By A. J. Moses and C. L. Parsons. Fifth edition; octavo (13.5 x 22.5 cm.), 575 illustrations, 631 pages. Price \$3.00 net. New York: D. Van Nostrand Company.

This well-known and much-used text-book is, in this edition, better than ever. There is no need to review its merits in detail, but the 200 additional pages and the many parts which have been rewritten deserve mention. The additions are of new groups and species, particularly those which have recently acquired economic importance; discussion of formation and occurrences of minerals, so as to link up more closely with geology; enlarged treatment of crystal-optics, especially with the aid of the polarizing microscope; new determinative tables; a simplified method of identifying crystal forms; a separate chapter on the gems and semi-precious stones. These additions are commendable, except that the optical part is developed much further than anyone but a specialist in mineralogy has time to go. The simplified method of identifying natural crystals by means of axes of symmetry and planes of symmetry is admirable; it is the exact method developed by the reviewer as most practical in his classes in crystallography some twenty years ago, and it is to be hoped that its adoption in Moses' and Parsons' book will assure its universal use.

The determinative tables could be much improved; they are crude and in spots inaccurate. The "key" headings should be reprinted at the head of each numbered division, to avoid constant reference back to the "key"; the blowpipe tests are not as prominent in the classification as their usefulness demands; ordinary qualitative wet tests are often noted where blowpipe tests would be easier, quicker and more certain. The classifying tests, for instance, are often uncertain; *e.g.*, Class I, A is "Black or Nearly," and covers lists 1 to 10, while Class I, B, "Silver-white, Tin-white or Gray," covering lists 11 to 20, includes at least six minerals which are often "nearly black." At the next revision we advise the authors to concentrate attention upon perfecting these determinative tables. As it stands, however, it is a highly useful book.

* * *

Chemical Tests for Minerals. By Arthur J. Burdick. 93 pages. Price \$1.25, postage 7 cents. Beaumont, Cal.: The Gateway Publishing Co.

This little book is described as an aid for the prospector in testing his samples qualitatively on the ground and has been written with that end in view. It gives descriptions of the various ores and specific tests for each of the minerals separately, and the method and tests necessary for making a general examination of the ore. A description is given of the outfit required and considerable helpful general information such as a tabulation of the solubility of the various minerals and a list of the physical properties of the various materials.

Personal

Mr. S. E. Allison, Woolworth Building, has been appointed New York representative of the Certain-Teed Products Corporation of Baltimore, Md.

Mr. James A. Campbell, president of the Youngstown Sheet & Tube Company, Youngstown, Ohio, has returned from Hot Springs, Ark., where he had been enjoying a vacation.

Mr. J. J. Carty, chief engineer of the American Telephone and Telegraph Company, New York City, and

past president of the American Institute of Electrical Engineers, has been commissioned senior major in the Signal Officers' Reserve Corps, the reserve auxiliary of the Signal Corps, U. S. A.

Mr. Harrison W. Craver, formerly chief librarian of the Carnegie Library of Pittsburgh, has been appointed director of the library of the United Engineering Societies of New York. Mr. Craven was the guest of honor at a dinner tendered to him on April 4 by the Library Committee of the United Engineering Society at the Engineers' Club.

Mr. Leon O. Hart, electrical engineer for the Driver Harris Wire Company, Harrison, N. J., has recently been appointed assistant treasurer of the company.

Mr. Ralph Hayden has recently resigned as superintendent of regrinding and flotation at Anaconda to accept the superintendency of the Quincy Stamp Mills at Mason, Mich.

Mr. Charles Holzworth, formerly superintendent of the Ella furnace at West Middlesex, Pa., has been appointed general superintendent of the Ella and Claire furnaces at West Middlesex. These furnaces are owned by E. W. Mudge & Company, with headquarters in the Frick Building, Pittsburgh, Pa.

Mr. A. E. Marshall, the well-known manager of The Thermal Syndicate, Ltd., New York City, will shortly sever his connection with that company to become works manager of the Curtis Bay, Md., plant of the Davison Chemical Co.

Dr. John A. Mathews, president of the Halcomb Steel Co., of Syracuse, N. Y., lectured before the Technology Club of Syracuse on March 19 on "The Electric Furnace in Steel Manufacture." He illustrated his lecture with numerous lantern slides.

Mr. L. J. O'Loughlin has recently changed his position from blast furnace engineer at the Cambria Steel Co., Johnstown, Pa., to chief engineer of the Wharton Steel Co., Wharton, N. J.

Mr. Lewis E. Saunders, general manager of the Norton Co., at Niagara Falls, is on a business trip in South America.

Mr. Maurice R. Thompson of the Power and Mining Department of the General Electric Company, Schenectady, N. Y., is making a western trip in the interests of the company. He will spend some time at the metallurgical centers in Arizona, Utah and Montana.

Mr. E. E. Watts, best known as the inventor of the Watts electrolytic zinc process, is now connected with the Consolidated Mining and Smelting Company of Canada, Ltd., at Trail, B. C.

Mr. Arthur E. Wells, metallurgist of the Salt Lake City Station of the Bureau of Mines recently visited Seattle, Wash. While in Seattle he visited the Bureau of Mines station, and from Seattle he went to Tacoma, where he visited the plant of the American Smelting & Refining Company. He then went to Anaconda, Mont., where he was to assist in the installation of apparatus for treating the smelter gases as representative of the Federal Smoke Commission.

CURRENT MARKET REPORTS

The Iron and Steel Market

The steel market experienced no shock from the United States entering the world war. Wall Street appraised the event by a slight decline in stock prices, but that reflected the prospect of earnings being heavily taxed to pay for the war, as far as may be, as we go. The furnishing of steel to the government at much below market prices cannot affect total earnings ma-

terially, the maximum tonnage that could be employed being but a small proportion of the aggregate output. Finished rolled steel is being made at the rate of more than 2,500,000 tons a month, and government requirements as thus far discussed are in terms of hundreds of thousands of tons, spread over delivery periods that in some cases exceed a twelvemonth.

The present and prospective government requirements, however, have exercised an important influence upon the general market situation, not so much on account of the total tonnage of steel involved, as on account of uncertainty in what forms the steel will be required. The industry is highly specialized. The individual stands of rolls have limited ranges. In some cases the range is large theoretically, but small practically when ingot producing capacity has been increasing apace for more than a year and rolling capacity not in proportion. To finish the ingots that can be cast the mills must make the sizes in which they can compass the largest tonnage. In 1914 the plate mills made a great deal of light stuff which in the two succeeding years was shoved over to the jobbing mills, and the jobbing mills in their turn shoved the lighter of their gages up to the sheet mills. The sheet mills might here and there have shoved some lighter gage orders to the tin mills, but the tin plate consumers saw them first.

In the circumstances steel mills have become much more reserved in the matter of making delivery promises. Much business has been put through, the aggregate bookings easily exceeding the shipments, but the business has been chiefly of routine character, mills booking their regular customers for additional contract periods, without any definite promise of when deliveries would actually be undertaken.

The trend of steel prices has been upward, though not more markedly so than in the past. There was a very stiff advance in standard steel pipe, five points or about \$9 a net ton, the largest single advance on record in this material, but pipe had been disproportionately low. Even with the present advance the spread between billets per gross ton and pipe per net ton is substantially the same in dollars as when both commodities were at their lowest.

The American Sheet & Tin Plate Company has opened its books for third quarter in the case of jobbers and second half in the case of manufacturing consumers, at the following prices for Bessemer stock: Tin plate, \$7.50 per base box; blue annealed sheets, 5c. for 10 gage, with the old gage differentials, in recent months practically disregarded; black sheets, 5.50c. for 28 gage; galvanized sheets, 7c. for 28 gage, with increased differentials for lighter gages. For all products an extra of 25 cents per 100 lb. is charged for open-hearth, a rule that will probably be rigidly enforced to conserve the supply of open-hearth steel. Independents had expected higher prices for tin plates and galvanized sheets at least, and are not booking freely.

Transportation conditions have continued to improve, although not rapidly. Supplies of coke have become very nearly adequate, and production of pig iron has reached a rate of 40,000,000 tons a year, a shade above the average rate in 1916, but a rate which was exceeded by nearly 10 per cent in October and November. Pig iron has become scarcer and prices continue on the upward trend, frequently with advances of a dollar a ton overnight. Valley prices are \$35 for basic and \$40 for Bessemer.

Steel production has increased slightly, not having decreased during the traffic congestion as much as pig iron production. Steel shipments are better, and stocks accumulated at mills during the winter are being reduced. The chief concern now is as to whether the

opening of the season of lake navigation, with its heavy requirements of coal to be moved to Lake Erie ports, and iron ore to be moved therefrom, will cause a fresh railroad congestion. Reports are that an unusual number of locomotives are in repair shops and that motive power next month will be more efficient than ever.

Non-Ferrous Metal Market

Saturday, April 7.—There have been no radical price changes in any of the metals during the past two weeks, and the markets for the most part have been quiet. It is impossible to say at this time just what effect the entry of the United States into the world war will have on the metal markets, as it is not known just what quantities the Government will need or how the normal consuming trade will be affected. It is probable, however, that considerable copper and lead will be needed, but the Government has placed a ban on excessive war profits and will take over the management of any plant that holds out for a price considered excessive.

Copper.—The recent action of some of the large copper producers in selling 45,000,000 lb. of copper to the Government at one-half market price, or about 16 2/3 cents per pound, is significant and as many munition makers have completed their foreign contracts, and production has been increased to such a large extent, a drop in the price of copper can be looked for at any time. It is understood that the Government will need 90,000,000 lb. more of copper shortly, and doubtless will need far more than this when the munition and other plants begin large production. The *American Metal Market* has prepared an interesting table showing where our copper exports have been going:

WHERE OUR COPPER EXPORTS ARE GOING			
	During February,	Jan. 1 to Feb. 28,	
(Short tons)	1917	1917	1916
United Kingdom	6,133	13,789	8,446
France	17,123	30,090	18,929
Germany .....	.....	.....	.....
Holland	431	456	407
Belgium .....	.....	.....	.....
Austria .....	.....	.....	.....
Italy	4,217	7,944	10,498
Denmark .....	.....	.....	390
Norway and Sweden	665	1,068	3,932
Russia	1,500	3,250	806
China and Japan .....	.....	7	22
Sundries	323	806	879
Total	30,392	57,350	44,311

At present electrolytic is quoted at 34.25 with lake at 34.50 for prompt shipment.

Tin.—The tin market has been quiet, with prices ruling fairly firm. A decline of about 1 1/2c. has taken place and spot Straits is now held at 54.75. Arrivals in March were 4804 tons, of which 1404 tons arrived at Pacific ports. It is likely that considerable more tin for tin cans will be needed during the next two years for shipping food products to Europe, provided the war goes on.

Spelter.—There is not much to be said about the spelter market. The spot New York quotation is 10.55c. The market has been featureless, but it may pick up if the brass manufacturers make shells on a large scale.

Lead.—The only change in the lead market has been a slight decline in the spot price of independents which is now 9.50c. The Trust price remains at 9.00c.

Other Metals.—Antimony has advanced 1 cent to 36.00. Spot is still scarce. Aluminium is quoted at 59.00-60.00c. for No. 1 virgin metal. Quicksilver is held at \$115.00 per flask, silver has advanced again and is now quoted at 73 3/4. On April 2 it was 74 1/4, having risen from 71 1/8 on March 26. Pure platinum is \$105.00 per ounce.

Chemical Market

The General Situation.—This review of the chemical situation is being written at the moment the tickers inform us the Declaration of War against the Imperial German Government is being placed before the President for his signature. Consequently to-day's markets for chemicals will mean little to-morrow. The great industry which American enterprise has developed during the past three years now faces its supreme test. Just what the government will do remains to be seen. Purchases will be made on an enormous scale, but abnormal profits will not be allowed. The margin of profit that will be allowed manufacturers is in doubt. The Entente governments have been allowing ten per cent margin, but it is stated that this percentage will be cut by Washington. Full authority has been given the Executive offices of the Government to take over and operate any plant that does not immediately agree to sell at the prices set by the Government. Already it is announced that one manufacturer who refused to sell at a set price has felt the influence of this new authority and has been notified that if he maintains his attitude he will find his plant in new operating hands shortly. Already the fertilizer industry has felt the influence of stirring current events. The Government has, according to reliable authority, commandeered the menhaden fishing vessels in the Chesapeake and ordered them to report to Norfolk. These swift light vessels of sturdy construction will presumably be armed and assume patrol duty similar to that of the English and Scotch trawlers.

Benzol.—The large producers now have the situation under better control than during any period of the past few months, and there is but little material now in outside hands. The independent producers are well sold up—in fact, most of them are not offering at all for delivery this year. The situation promises much from a sellers' viewpoint and indications seem to point to higher values.

Toluol.—There can now be but little doubt that large purchases of toluol will be made by the Government for T N T purposes and as a consequence the word "firmness" hardly describes the situation. During the fortnight the actual transactions reported were comparatively small. Firms controlling supplies are apparently content to sit back and await developments which seemingly are to be in their decided favor.

Phenol.—Despite continued strength in practically all products entering into munition manufacture, phenol rules easy. Competition has been too keen and production has apparently exceeded the supply. However, picric acid business is surely to appear soon, as this is at least one hope that it held out to makers.

Diphenylamine.—This stabilizer has been in urgent request, and the few producers report supplies well sold up with prices higher than have prevailed for some time.

Aniline Oil and "Salt."—A large producer of oil who is now consuming his own product has been in the market for an important tonnage during the interval with the result that prices have recorded substantial advances. Supplies are light and spot shipments are difficult to produce. "Salt" has advanced more in proportion than oil.

Monochlorbenzol.—Production has gradually increased and some makers are now offering stocks for immediate and future shipment. The tight situation recently noted has eased.

Toluidines.—There has been a very brisk demand for the *para* as a result of the explosion in one of the producing plants. Prices have advanced sharply. *Ortho* has also experienced more than an ordinary inquiry.

Paranitrotoluol.—A number of consumers have inquired for this material, but producers are well sold out and but little material is reaching outside hands.

Paranitrosodimethylaniline (base).—Rubber manufacturers have been much interested in this product and some sales have passed on the basis of \$3.50 for immediate shipment with contracts somewhat easier. Offers seem to be confined to but one source, and this factor states that regular supplies will be available from now on.

Heavy Chemicals.—The general position of products under this classification has been higher throughout the interval, and considerable business has transpired.

Caustic Soda and Soda Ash.—There has been important business transpiring in the alkalis during the interval and prices have steadily climbed. The export movement in caustic remains heavy and will probably continue so. Domestic consumers have been in the market in a large way as far forward as 1918, and a number of the leading producers are sold out. **Formaldehyde** has been in urgent inquiry for export to England. Spot stocks have been practically nil and buyers have taken up every offer made promptly. **Nitrite of soda**, in the absence of important supplies, has advanced 75 per cent in value, and both domestic producers are sold out. **Nitrate of soda** has been steady but the demand has not been urgent. **Bleaching powder** has been somewhat easier. **Acetate of lime** has taken a sharp advance due, it is stated, to the difficulty of getting coal supplies to the wood distillation plants which are situated at very remote points. **Acetone** has advanced sharply in sympathy. Probably the anticipated demand for this product had more to do with the advance in acetate of lime than the shortage of coal. In acids, **acetic** has again scored an advance. **Muriatic** is off and supplies are more than abundant. **Nitric acid** in contrast has been very firm and prices are again higher. There has been a very good demand for **sulphuric acid**, particularly the brimstone variety.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 6, 1917

Acetic anhydride	lb.	1.75	—	2.00
Acetone, drums	lb.	.27	—	.27 1/2
Acid, acetic, 28 per cent.	lb.	.04 1/2	—	.05 1/2
Acetic, 56 per cent.	lb.	.09	—	.09 1/2
Acetic, glacial, 99 1/2 per cent, carboys.	lb.	.27	—	.30
Boric, crystals	lb.	.11	—	.12
Citric, crystals	lb.	.76	—	.78
Hydrochloric, commercial, 18 deg.	lb.	.01 1/4	—	.01 3/4
Hydrochloric, 20 deg.	lb.	.01 3/8	—	.01 1/2
Hydrochloric, C. P., conc. 22 deg.	lb.	.01 5/8	—	.01 3/4
Hydrofluoric, 30 per cent, in barrels.	lb.	.04 1/2	—	.05
Lactic, 44 per cent.	lb.	.10 1/2	—	.12
Lactic, 22 per cent.	lb.	.05	—	.05 1/4
Nitric, 36 deg.	lb.	.05 1/4	—	.05 1/2
Nitric, 42 deg.	lb.	.06 1/2	—	.07
Oxalic, crystals	lb.	.46	—	.48
Phosphoric, 85 per cent.	lb.	.29	—	.31
Picric	lb.	.70	—	.75
Pyrogallol, resublimed	lb.	3.50	—	—
Sulphuric, 60 deg.	ton	19.00	—	20.00
Sulphuric, 66 deg.	ton	28.00	—	30.00
Sulphuric, oleum (Fuming), tank cars.	ton	35.00	—	36.00
Tannic, U. S. P. bulk.	lb.	.45	—	.48
Tartaric, crystals	lb.	.84	—	.86
Alcohol, grain, 188 proof.	gal.	2.78	—	2.80
Alcohol, wood, 95 per cent.	gal.	1.00	—	1.02
Alcohol, denatured, 180 proof.	gal.	.70	—	.72
Alum, ammonia, lump.	lb.	.04	—	.04 1/2
Alum, chrome ammonium	lb.	.18	—	.20
Alum, chrome potassium	lb.	.35	—	.40
Alum, chrome sodium	lb.	.22	—	.24
Alum, potash lump	lb.	.05 1/2	—	.06
Aluminium sulphate, technical	lb.	.01 1/4	—	.02
Aluminium sulphate, iron free.	lb.	.03 3/4	—	.03 1/2
Ammonia aqua, 26 deg. carboys.	lb.	.05 1/4	—	.05 3/4
Ammonium carbonate	lb.	.14	—	.15
Ammonium nitrate	lb.	.14 1/2	—	.16
Ammonium sulphate domestic	lb.	.05	—	.06
Amyl acetate	gal.	4.50	—	4.55
Arsenic, white	lb.	.15 3/4	—	.16 1/2
Arsenic, red	lb.	.35	—	.60
Barium chloride	ton	90.00	—	95.00
Barium sulphate (Blanc Fixe) powder.	lb.	.04	—	.04 1/4
Barium nitrate	lb.	.11 1/4	—	.11 1/2
Barium peroxide, basis 70 per cent.	lb.	.28	—	.30
Bleaching powder, 35 per cent chlorine, domestic, drums	lb.	.03 3/4	—	.03 3/4
Borax, crystals, sacks.	lb.	.07 1/2	—	.08
Brimstone, crude	ton	45.00	—	—
Bromine, technical	lb.	.90	—	1.00

Calcium, acetate, crude.....lb.	.03	—	.03 1/2
Calcium, carbide.....ton	80.00	—	90.00
Calcium chloride, 70-75 per cent, fused, lump.....ton	27.50	—	30.00
Calcium peroxide.....lb.	1.70	—	1.75
Calcium phosphate.....lb.	.30	—	.33
Calcium sulphate.....lb.	.01 1/4	—	.01 1/2
Carbon bisulphide.....lb.	.04	—	.04 1/2
Carbon tetrachloride, drums.....lb.	.16	—	.17
Caustic potash, 82-92 per cent.....lb.	.76	—	.78
Caustic potash, 70-75 per cent.....lb.	.64	—	.66
Caustic soda, 76 per cent.....lb.	.043	—	.044
Chlorine, liquid.....lb.	.15	—	.16
Copperas.....100 lb.	1.05	—	1.15
Copper carbonate.....lb.	.35	—	.38
Copper cyanide.....lb.	.75	—	.80
Copper sulphate, 99 per cent, large crystals.....lb.	.09 1/2	—	.10
Cream of tartar, crystals.....lb.	.43 1/2	—	.44
Epsom salt, bags.....100 lb.	3.50	—	4.00
Formaldehyde, 40 per cent.....lb.	.13 1/4	—	.14
Glauber's salt.....100 lb.	.60	—	.70
Glycerine, bulk, C.P.....lb.	.55 1/2	—	.56
Iodine, resublimed.....lb.	3.50	—	3.55
Iron oxide.....lb.	.02	—	.10
Lead acetate, white crystals.....lb.	.14	—	.16
Lead arsenate.....lb.	.11	—	.12
Lead nitrate.....lb.	.16 1/2	—	.17
Litharge, American.....lb.	.08 1/2	—	.10
Lithium carbonate.....lb.	1.03	—	1.04
Manganese dioxide.....lb.	.60	—	.65
Magnesium carbonate, tech.....ton	44.00	—	46.00
Nickel, salt, single.....lb.	.14	—	—
Nickel, salt, double.....lb.	.11	—	—
Phosphorous, red.....lb.	1.10	—	1.15
Phosphorous, yellow.....lb.	1.05	—	1.10
Potassium bichromate.....lb.	.35	—	.36
Potassium bromide granular.....lb.	1.00	—	1.01
Potassium carbonate calcined, 80-85 per cent.....lb.	.32	—	.38
Potassium chlorate, crystals.....lb.	.58	—	.60
Potassium cyanide, 98-99 per cent.....lb.	1.60	—	1.65
Potassium iodide.....lb.	2.90	—	2.95
Potassium muriate, 80-85 p.c. basis of 80 p.c. ton.....390.00	—	—	400.00
Potassium nitrate.....lb.	.30	—	.31
Potassium permanganate.....lb.	2.30	—	2.50
Potassium prussiate, red.....lb.	2.50	—	2.75
Potassium prussiate, yellow.....lb.	.90	—	.92
Potassium sulphate, 90-95 p.c. basis 90 p.c. ton.....270.00	—	—	275.00
Rochelle salts.....lb.	.36	—	.37
Sal ammoniac, gray gran.....lb.	.10	—	.11
Sal ammoniac, white gran.....lb.	.17 1/2	—	.18
Sal soda.....100 lb.	1.05	—	1.10
Salt cake.....100 lb.	.90	—	1.00
Silver cyanide.....oz.	.70	—	—
Silver nitrate.....oz.	.45 1/2	—	.47 1/2
Soda ash, 55 per cent, light, flat.....lb.	.0315	—	.0320
Soda ash, 55 per cent, dense, flat.....lb.	.036	—	.038
Sodium acetate.....lb.	.09	—	.10
Sodium benzoate.....lb.	6.50	—	7.00
Sodium bicarbonate, domestic.....100 lb.	1.90	—	2.00
Sodium bicarbonate, English.....lb.	—	—	Nominal
Sodium bichromate.....lb.	.16	—	.18
Sodium bisulphite, powdered.....lb.	.04 1/4	—	.04 1/2
Sodium chloride.....lb.	.24	—	.26
Sodium cyanide.....lb.	1.00	—	1.05
Sodium fluoride, commercial.....lb.	.11 1/2	—	.12
Sodium hyposulphite.....lb.	.01 1/2	—	.02
Sodium nitrate, refined.....lb.	.05 1/4	—	.05 1/2
Sodium nitrate.....lb.	.22	—	.24
Sodium peroxide.....lb.	.95	—	1.00
Sodium phosphate(tri.).....lb.	.04 1/2	—	.05
Sodium prussiate, yellow.....lb.	.32	—	.33
Sodium silicate, liquid, 40 deg.....100 lb.	1.05	—	1.25
Sodium silicate, liquid, 60 deg.....100 lb.	2.00	—	2.25
Sodium sulphide, 30 per cent crystals.....lb.	.02 1/2	—	.03
Sodium sulphide, 60 per cent fused.....lb.	—	—	—
Sodium sulphite.....lb.	.03 1/4	—	.03 1/2
Strontium nitrate.....lb.	.28	—	.30
Sulphur chloride, drums.....lb.	.10 1/4	—	.10 1/2
Sulphur, dioxide, liquid, in cylinders.....lb.	.11 1/2	—	.12
Sulphur, flowers, sublimed.....100 lb.	2.55	—	2.75
Sulphur, roll.....100 lb.	2.35	—	2.45
Sulphur, crude.....45.00	—	—	—
Tin bichloride, 50 deg.....lb.	.14 1/2	—	.15
Tin oxide.....lb.	.56	—	.57
Zinc carbonate.....lb.	.24	—	.25
Zinc chloride.....lb.	.16	—	.18
Zinc cyanide.....lb.	.50	—	—
Zinc dust.....lb.	.18	—	.20
Zinc oxide, American process XX.....lb.	.11 1/2	—	.12
Zinc sulphate.....lb.	.06 1/2	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white.....gal.	.58	—	.60
Benzol, 90 per cent.....gal.	.56	—	.58
Toluol, pure, water white.....gal.	1.75	—	1.90
Xylol, pure, water white.....gal.	.55	—	1.00
Solvent naphtha, water white.....gal.	.18	—	.20
Solvent naphtha, crude heavy.....gal.	.14	—	.16
Creosote oil, 25 per cent.....gal.	.32	—	.35
Dip oil, 20 per cent.....gal.	.28	—	.30
Pitch, various grade.....ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent.....lb.	.90	—	.95
Carbolic acid, crude, 50 per cent.....lb.	.48	—	.50
Carbolic acid, crude, 25 per cent.....lb.	.23	—	.25
Cresol, U. S. P.....lb.	.20	—	.21

Intermediates, Etc.

Alpha naphthylamine.....lb.	1.10	—	1.25
Aniline oil.....lb.	.28	—	.28 1/2
Aniline salts.....lb.	.33	—	.35
Anthracene, 80 per cent.....lb.	.10	—	—
Benzaldehyde.....lb.	4.00	—	4.50
Benzidine, base.....lb.	1.75	—	1.80
Benzidine sulphate.....lb.	1.50	—	1.55
Benzole acid.....lb.	7.00	—	7.25
Beta naphthol, sublimed.....lb.	.80	—	.85

Dichlor benzol.....lb.	.32	—	.34
D-nitro chlor benzol.....lb.	.46	—	.48
Dimethylaniline.....lb.	.55	—	.58
Diphenylamine.....lb.	.90	—	1.00
H-acid.....lb.	—	—	Nominal
Metaphenylenediamine.....lb.	1.45	—	1.60
Monochlorobenzol.....lb.	.35	—	.37
Naphthalene, flake.....lb.	.09 1/2	—	.10
Naphthionic acid, crude.....lb.	1.25	—	2.00
Nitro naphthalin.....lb.	.45	—	.60
Ortho-amidophenol.....lb.	—	—	—
Ortho-toluidine.....lb.	1.20	—	1.25
Para-amidophenol base.....lb.	4.50	—	4.75
Paranitraniline.....lb.	1.20	—	1.25
Paraphenylenediamine.....lb.	3.50	—	3.75
Para toluidine.....lb.	2.00	—	2.25
Phenol, U. S. P.....lb.	.43	—	.45
Rezorcin, technical.....lb.	9.00	—	—
Resorcin, pure.....lb.	16.00	—	17.00
Salicylic acid.....lb.	.80	—	.85
Salol.....lb.	1.50	—	1.75
Sulphanilic acid.....lb.	.31	—	.32
Tolidin.....lb.	3.00	—	—
Toluidine-mixture.....lb.	.80	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania.....bbl.	3.05	—	—
Corning, Ohio.....bbl.	2.38	—	—
Somerset, Ky.....bbl.	2.18	—	—
Wooster, Ohio.....bbl.	2.05	—	—
Indiana.....bbl.	1.73	—	—
Illinois.....bbl.	1.87	—	—
Oklahoma and Kansas.....bbl.	1.70	—	—
Caddo, La., light.....bbl.	1.90	—	—
Corsicana, Tex., light.....bbl.	1.70	—	—
California.....bbl.	.73	—	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.....gal.	13 1/2	—	14
Cylinder, light.....gal.	.21	—	.26
Cylinder, dark.....gal.	.18	—	.19
Extra cold test.....gal.	.26	—	.31
Paraffine, high viscosity.....gal.	.29 1/2	—	.30
Paraffine, 903 sp. gr.....gal.	.21 1/2	—	.22
Paraffine, 865 sp. gr.....gal.	.18 1/2	—	.19

Flotation Oils

Pine oil, steam distilled.....gal.	.59	—	—
Pine oil, destructively distilled.....gal.	.47	—	—
Pine-tar oil.....gal.	.19	—	—
Pine-tar oil, double refined.....gal.	.30	—	—
Pine oil, light.....gal.	.37	—	—
Pine oil, heavy.....gal.	.26	—	—
Turpentine, crude.....gal.	.38	—	—
Pine tar, thin.....gal.	.18	—	—
Hardwood oil, f.o.b. Michigan.....gal.	.16	—	—
Creosote, coal tar neutral.....gal.	.15	—	—
Creosote, coal tar, acid.....gal.	.21	—	—

Vegetable and Other Oils

China wood oil.....lb.	.14	—	.14 1/2
Cottonseed oil, crude.....gal.	.95	—	—
Linseed oil, raw, cars.....gal.	1.04	—	—
Peanut oil, crude.....gal.	1.00	—	—
Rosin oil, first run.....gal.	.38	—	—
Rosin oil, fourth run.....gal.	.67	—	—
Soya bean oil, Manchuria.....lb.	.13 1/2	—	—
Turpentine, spirits.....gal.	.48	—	—

Miscellaneous Materials

Barytes, floated, white foreign.....ton	38.00	—	40.00
Barytes, floated, white, domestic.....ton	28.00	—	32.00
Beeswax, white pure.....lb.	.52	—	—
Carnauba wax, highest grade.....lb.	.51	—	—
Chalk, light, precipitated, English.....lb.	.03	—	.06
Feldspar.....ton	8.00	—	12.00
Fuller's earth, powdered.....100 lb.	.80	—	1.05
Red lead, dry, carloads.....lb.	10 1/2	—	—
Rosin, 280 lb.....bbl.	6.00	—	—
Soapstone.....ton	10.00	—	12.50
Talc, American, white.....ton	10.00	—	13.00
White lead, dry.....lb.	.09 1/4	—	—

Refractories, Etc.

(F.O.B. Works)

Chrome brick.....net ton	—	—	Nominal
Chrome cement, Grecian.....net ton	60.00	—	—
Clay brick, 1st quality fireclay.....per 1000	45.00	—	—
Clay brick, second quality.....per 1000	30.00	—	—
Magnesite, Grecian, dead burned.....net ton	90.00	—	—
Magnesia brick, Grecian, 9x4 1/2 x 2 1/2.....net ton	140.00	—	—
Silica brick.....per 1000	45.00	—	—

Ferroalloys

Ferro-carbon-titanium, carloads.....lb.	12 1/2	—	—
Ferrochromium.....lb.	—	—	Nominal
Ferromanganese, domestic, delivered.....ton	300.00	—	325.00
Ferromanganese, English.....ton	185.00	—	—
Ferromolybdenum, per lb. of Mo.....lb.	4.00	—	—
Ferrosilicon, 50 per cent carloads del. Pitts- burgh.....ton	200.00	—	250.00
Ferrosilicon, 50 per cent, contract.....ton	100.00	—	—
Ferrotungsten, 75-85 per cent, f.o.b. Pitts- burgh.....lb.	1.95	—	—
Ferrovandium f.o.b. works.....lb.	2.75	—	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

Air Reduction Co. has been incorporated in California with a capital of \$100,000 to produce and deal in oxygen and other gases. The main office is at 120 Broadway, New York.

The Alpha Chemical Works, Inc., has been chartered to manufacture and deal in drugs, chemicals, etc., with \$1,000,000 capital, by A. W. Britton, S. B. Howard and L. H. Gunter, all of New York City.

American Colors, Inc., Philadelphia, Pa., has been incorporated with a capital of \$200,000 to manufacture and deal in colors, dyestuffs and chemicals.

Ampco Rolling Mills Corp., Delaware, has been incorporated with a capital of \$1,000,000 to buy, lease and develop and control steel and bronze metal rolling mills. The incorporators are Edgar E. Warner, Peter Weber, A. E. Martin, Milwaukee, Wisconsin.

Associated Rolling Mills, Ltd., New York, has been incorporated with a capital of \$50,000 to do business in metal products, manufacturing, engineering, contracting. The incorporators are W. F. Keers, E. M. Higgins, H. J. Baily, 32 Liberty Street.

Blandon Rolling Mills, Inc., Harrisburg, Pa., has been incorporated with a capital of \$150,000. Incorporator Samuel R. Seyfert.

O. A. Brown Co., Inc., New York, has been incorporated with a capital of \$100,000 to deal in essential oils, materials, edible, synthetic oils, dyestuffs, chemicals, perfumes, soaps. The incorporators are E. C. O. Thomas, A. O. O'Connell, O. A. Brown, 344 West 72d Street.

Carnation Copper Co., Delaware, has been incorporated with a capital of \$1,500,000 to mine for gold, copper, silver and other ores and metals. The incorporators are Herbert E. Latter, Norman P. Coffin, Clement M. Egner, Wilmington, Del.

Castle Valley Sulphur Co., Charleston, W. Va., has been incorporated with a capital of \$26,000 to deal in and refine sulphur and other minerals. The incorporators are Chas. H. Henning, Lee Ott and A. B. Bright.

Chemical Manufacturing Company, Inc., Brooklyn, New York, has been incorporated with a capital of \$150,000. The incorporators are James J. Nevin, Mollie Nevin and Mendel Nevin of Brooklyn.

Corporation for Chemical Industry, Philadelphia, Pa., has been incorporated with a capital of \$100,000 to manufacture and sell dyes, oils and coal tar. The incorporators are F. R. Hansell, Philadelphia; Martin and Seymour, Camden, N. J.

Eastern Talc Co., Portland, Me., has been incorporated with a capital of \$750,000 to produce and prepare, manufacture and deal in talc and similar substances.

Firman Potash Company, Los Angeles, Cal., has been incorporated with a capital of \$100,000. The incorporators are Dr. John M. Cleaver, Arthur H. Firman, Chas. F. Tanner, A. O. Hoyt, Harry J. Mumma.

The General Silica Company, chartered under the laws of Delaware by Paul Hyde, C. L. Shaffer and John W. Pitt, all of Chicago, Ill., to produce, grind and mine for felspar, silica, with \$1,000,000 capital.

A. L. Goesslin Corporation, New York, has been incorporated with a capital of \$50,000. Chemicals, dyestuffs, food products, canned goods. The incorporators are J. E. Roesser, J. R. Meyer, A. L. Goesslin, 20 West 59th Street, N. Y. C.

Great American Chemical Products Co., Inc., Dover, Del., has been incorporated with a capital of \$10,000,000 to carry on a general business of chemist and druggists, etc. The incorporators are Herbert E. Latter, Norman P. Coffin, Clement M. Egner, Wilmington, Del.

The Hamilton Furnace Co., Columbus, Ohio, has been incorporated with a capital of \$400,000. The incorporators are John A. Savage, J. E. McCloskey, E. E. Gillespie, F. J. Lashley and J. C. Alextinder.

Hatch Glass Sand Corp., Buffalo, N. Y., has been incorporated with a capital of

\$25,000 to deal in sand, gravel, stone. The incorporators are C. T. Hurley, V. E. O'Grady, C. C. Hatch, 62 Imeson Street, Buffalo, N. Y.

Hy-Carbo Steel Co., Lowell, Mass., has been incorporated with a capital of \$20,000. The incorporators are Chas. H. Bagshaw, 79 Wedge Street, Lowell; I. E. Higgins and M. C. Bagshaw.

The Indianapolis Foundry Company, Indianapolis, Ind., has been reorganized with a capital of \$175,000. The new name of the company is the Indianapolis Castings Company. The company operates a plant near South Harding and West Washington Streets. The incorporators were Frank E. Lewis, John Wallace and Charles O. Roemer. Mr. Lewis has been president of the Indianapolis Foundry Company for a number of years. He will continue in the management of the new company. Castings and similar products are manufactured at the plant. The plant has been in operation in Indianapolis for twenty-five years.

The Jackson County Oil Co., has been organized at Berea, Ky., with \$40,000 capital by D. H. Welch, J. C. Gilbert and W. M. Farmer.

James & Breckler, Louisville, Ky., has been incorporated with a capital of \$6,000 to manufacture chemicals. The incorporators are W. E. James, New Albany; A. M. Breckler, Louisville; E. Danenbaum, Des Moines; Thomas Edwards, Clarksville.

Laclede Chemical Company, St. Louis, Mo., has been incorporated with a capital of \$5,000 to manufacture coal-tar products. The incorporators are C. T. Swarts, E. C. Edminston, T. H. Budke, J. R. Glasco.

The Latem Metal Company, Newark, N. J., has been incorporated with a capital of \$55,000 to manufacture chemicals for the treating of iron, steel, copper and other metals. The incorporators are George C. Helmick, William H. Perrine and Ernest H. Fougner, Newark.

Leather Processes, Inc., Manhattan, has been incorporated with a capital of \$7,500 to manufacture articles used in tanning and production of leather goods. The incorporators are E. J. Weasels, F. R. Pentlarge and E. C. Fischer, Newark, N. J.

Majestic Mills Paper Co., New York City, has been incorporated with a capital of \$4,500 to manufacture paper, cardboard, twine, etc. The incorporators are A. Warshaw, William George Green, S. A. Giacobbe.

Medina Fullers Earth Company, San Antonio, Tex., capital \$100,000; to mine fullers earth and kaolin, prepare for market and manufacture into other articles. O. T. Gregory, E. D. Henry and L. R. Parker.

Melrose Chemical Co., Newark, N. J., has been incorporated with a capital of \$2,000 to deal in chemicals. The incorporators are John H. Fertig, Montclair; Alexander A. Bergner, Newark; Louis Pivarnich, New York.

H. A. Metz Laboratories, Inc., New York, has been incorporated with a capital of \$100,000 to deal in drugs, medicines, paints, chemicals. The incorporators are C. Fuehrlein, G. P. and H. A. Metz, 122 Hudson Street.

Millard Copper Company, New York, has been incorporated with a capital of \$50,000 to deal in copper, lead, zinc, etc. The incorporators are A. W. Britton, S. B. Howard and L. H. Gunther, all of New York.

The Millasier Mining Corporation, New York City, has been incorporated with \$100,000 capital by R. H. Rixon, Peekskill; H. W. Harrison, M. Olyphant, 66 Broadway, New York. The company is authorized to conduct a mining, smelting and refining business.

Mineroll Company, New York, has been incorporated with a capital of \$10,000. Business: mining, smelting. The incorporators are A. M. and W. A. Dvorkind, and Dr. A. H. Malaney, Atlanta, Ga.

The Mo-Ark Oxygen Company, St. Louis, Mo., has been incorporated with \$25,000 capital to manufacture oxygen, by Rudolph Best, Louis Rosen and B. T. Clifford.

Monarch Oil & Chemical Company, Philadelphia, Pa., has been incorporated with a capital of \$60,000 to deal in oil and other

products. The incorporators are Frank E. Lamb, Reuben Dierwechrt, and George W. Livezly, all of Philadelphia.

Natura Chemical Corporation, Buffalo, N. Y., has been incorporated with a capital of \$100,000 to deal in chemicals and drugs. The incorporators are H. M. Weiss, R. C. and F. E. Holland, 140 Goulding Avenue, Buffalo, N. Y.

National Carbon Coated Paper Company, Cleveland, Ohio, has been incorporated with a capital of \$300,000. Incorporator, C. L. Spence.

New York and Pennsylvania Gasoline Corp., Buffalo, N. Y., has been incorporated with a capital of \$250,000 to buy lands and produce oil. The incorporators are C. B. and L. Runyon, J. P. Hanlon, 62 Irving Place, Buffalo.

Oklahoma-Kansas Oil & Mining Company, Wilmington, Del., has been incorporated with a capital of \$2,000,000 to acquire oil lands and develop same.

Oklahoma-Kentucky Oil Company, Frankfort, Ky., has been incorporated with a capital of \$25,000,000. The incorporators are George B. Williams, Irvine; W. A. Aule, Kansas City; D. Lacy, P. O. Dings, H. Wallace and Roy M. Johnson, Ardmore; Ed. Dunlap, Ardmore; B. V. Hole, Burlingame, Cal.; W. M. Bonner, Oklahoma City; C. J. Sipple, London, Ky.

The Panoleum Corporation, New York, has been incorporated with a capital of \$10,000 to deal in metals, oils, paper, rags, waste, etc. The incorporators are A. G. Howard, H. J. Boneberg and George K. Mantz, all of Buffalo.

Paraloid Works, Inc., Yonkers, N. Y., has been incorporated with a capital of \$80,000 to deal in celluloid, imitation ivory, glass, amber, ivory, rubber, linen. The incorporators are S. L. Jackson, F. C. Pitcher, H. H. Schneider, Hastings-on-Hudson.

Penn Keystone Company, New York City, and Penn Keystone Graphite & Paint Company have been consolidated under the name of Penn Keystone Company of New York City.

The Petrol Refining Process, Inc., has been incorporated with a capital of \$100,000 to deal in mining, treating coal and oils. The incorporators are L. Pfeiffer and W. P. Engelman, 265 Oakland Avenue, West New Brighton.

The Pfanstiehl Company, Millbrook, N. Y., has been incorporated with a capital of \$405,000 to manufacture metals of all kinds and products. The incorporators are Jerome M. Frank, A. L. Schwartz and H. S. Gould.

Pittsburgh Compound Company, Pittsburgh, Pa., has been incorporated with a capital of \$10,000 to deal in oils, greases, etc. The incorporators are William McK. Scott, S. M. Long, Joseph W. Henderson, Pittsburgh.

Pollock Ink Works, Inc., Buffalo, N. Y., has been incorporated with a capital of \$25,000 to deal in ink, dyes, varnishes, coloring materials. The incorporators are C. A. Laawall, H. and C. M. Kart, Buffalo.

Red-Lock Products Co., Dover, Cal., has been incorporated with a capital of \$1,000,000 to manufacture and deal in drugs, etc. The incorporators are Charles H. Jones, George W. Morgan, W. I. M. Lofland, all of Dover.

Rochester Essential Products Co., Inc., Rochester, N. Y., has been incorporated with a capital of \$50,000 to deal in poultry, birds and animal foods, remedies, merchandise, drugs, stationery. The incorporators are G. Lee, E. Clarke, W. A. Matson, 15 Rochester Savings Bank, Rochester, New York.

The Royal Improvement Co., has been organized at Covington, Ky., by Emery N. Davis, Cacer Young, T. J. Kirkpatrick and others with \$500,000.

The Roxana Petroleum Company, Richmond, Va., has been incorporated with a capital of \$60,000,000 to engage in general oil development enterprises. The incorporators are Thomas B. Gay of Richmond, Va., president; B. Rice, Tulsa, vice-president; W. L. McGrady of Bayonne, N. J., secretary and treasurer.

The Sanitary Coating Co., Wilmington, Del., has been incorporated with a capital of \$200,000 to manufacture all kinds of paper and paper substitutes.

Sanolene Company, Inc., Rochester, N. Y., has been incorporated with a capital of \$14,000 to deal in soap, dye, disinfectants and chemicals. The incorporators are J. A. Hotchkiss, S. D. Hadcliffe and G. W. Heath, 249 Elm Street, Rochester.

Simley Steel Company, New York, has been incorporated with a capital of \$5,000 to manufacture steel and manganese. The

incorporators are J. F. O'Neill, Leo R. Healy and D. D. Vincent, Manhattan.

Sunbeam Chemical Company, Chicago, Ill., has been incorporated with a capital of \$25,000 to manufacture and deal in soaps, dyes and chemicals.

The Sunset Oil Company, Cheyenne, Wyo., has been incorporated with a capital of \$5,000,000. The incorporators are A. A. Spaugb, W. P. Spaugb of Manville, and J. A. Manorgan and Thomas H. Blair of Colorado.

Suor Oil Products Corp., Buffalo, N. Y., has been incorporated with a capital of \$300,000 to manufacture petroleum products. The incorporators are C. T. Hurley, V. E. O'Grady, E. J. Suor, 1276 Main Street, Buffalo, N. Y.

Sutphin Paper Co., New York City, has been incorporated with a capital of \$50,000, to manufacture paper and wood pulp. The incorporators are Henry T. Sutphin, Joseph H. Sutphin, John T. Leal.

Tanner Plant and Oil Co., Inc., Richmond, Va., has been incorporated. The incorporators are William E. Tanner, E. M. Long, both of Richmond.

Torchwood Equipment Company, Wilmington, Del., has been incorporated with a capital of \$100,000 to manufacture all kinds of metal weldings, brazing, etc. The incorporators are M. B. Gatchell, L. A. Irwin, Harry W. Davis, all of Wilmington, Del.

Tubular Steel Drug Corporation, Manhattan, has been incorporated with a capital of \$100,000 to conduct business of mining, smelting, rolling, mill, stamping, etc. The incorporators are W. J. Shilliday, W. E. Perry, A. E. Foye, 2 Rector Street, New York City.

The Tulsa Paper Company, Tulsa, Okla., has been incorporated with a capital of \$50,000. The incorporators are R. Hirschland, Oklahoma City; D. Martin Trees, Tulsa, and A. N. Jochem, Oklahoma City, Okla.

The Union Wood Flour Company, Hudson Falls, N. Y., has been incorporated with a capital of \$30,000 to manufacture pulp and paper. The incorporators are J. J. Cunningham, P. J. Reilly and E. C. Rogers of Hudson Falls.

United Dyes Corporation, 175 Smith Street, Perth Amboy, N. J., has been incorporated with a capital of \$500,000 to manufacture dyes, chemicals, etc.

The United Gas Products Company, Wilmington, Del., has been incorporated with a capital of \$200,000 to manufacture and deal in oxygen, hydrogen and other gases.

United States Fluorspar & Lead Company, Wilmington, Del., has been incorporated with a capital of \$300,000.

Vacuum Gasoline Company, Lawrenceville, Ill., has been incorporated with a capital of \$100,000 to produce and manufacture gas, gasoline and petroleum.

The Vendette-Alberta Oil Company, Providence, R. I., has been incorporated with a capital of \$100,000; 10,000 shares of \$10 each. The incorporators are Edmond Vandette and Nicholas G. Votolato of Providence; Lester T. Murphy, West Warwick.

Vermont Products Co., Utica, N. Y., has been incorporated with a capital of \$500,000 to deal in lumber lands, wood products, paper, chemicals, cements, paints, oils, scientific apparatus. The incorporators are H. Ferris, D. F. Strobel, J. M. Richards, Herkimer.

The Webb Chemical Co., St. Louis, Mo., has been incorporated with a capital of \$50,000 to deal in and manufacture toilet preparations, poultry remedies and similar articles. The incorporators are A. T. Webb, W. O. Baker and H. E. J. Lake.

The Wichita Independent Consolidated Companies, Dover, Del., has been incorporated with a capital of \$25,000,000 to produce and sell crude petroleum and products and acquire mineral lands and develop same. The incorporators are H. J. Buser, A. F. Buser, F. A. Beach, C. J. Carney and W. D. Jochems of Wichita, Kan.

Financial Reports, Capital Increases, Etc.

Directors of the Sharon Steel Hoop Company met recently in the principal offices in Sharon, Pa., for the purpose of discussing details of the absorption of the Youngstown Iron & Steel Company. Plans for the formation of the new holding company were also considered. The meeting was called by Mr. Severn P. Ker, president. Plans are being formulated to float a bond of \$2,000,000. It is stated, to finance the deal. Shareholders of the local company given the right to subscribe in stock of the new concern up

to par value of their holdings, have taken about \$1,250,000 stock.

The J. Y. J. Corporation of Pennington, N. J., manufacturers of sulphur dyes, has changed its title to the Westover Chemical Company. In addition to manufacturing sulphur colors, this company will make other colors and chemicals related to the color trade.

The Chemical Catalogue Company, Inc., has increased its capital from \$25,000 to \$50,000.

The Ferro Machine and Foundry Company, Cleveland, Ohio. Increase from \$1,000,000 to \$1,750,000.

Lake Erie Smelting & Refining Co., Cleveland, Ohio. Increase from \$50,000 to \$80,000.

The National Drawn Steel Company, East Liverpool, Ohio. Increase from \$150,000 to \$300,000.

Royal Silver Manufacturing Co., Inc., Norfolk, Va. Increase from \$25,000 to \$50,000.

Schlesinger Radium Company, Inc., New York City. Increase from \$100,000 to \$150,000.

Slocum, Avram & Slocum Laboratories, Inc., New York City. Increase from \$100,000 to \$200,000.

The Spencer Metal Products Co., Spencer, Ohio. Increase from \$25,000 to \$50,000.

The Commonwealth Acid Phosphate Company of New York City has changed its name to the Commonwealth Chemical Company.

The Libbey Glass Co., Toledo, Ohio, has increased its capital from \$1,000,000 to \$2,500,000. Expansion in the Sandusky and Toledo plants in the purchase of new machinery accounts for this increase, according to William F. Donovan, assistant treasurer. Several new lines of glass making machinery will be manufactured both in the local and in the Sandusky plants. The improvements will take place within the next two years.

The Northwestern Chemical Company, Marietta, Ohio, has increased its capital from \$20,000 to \$150,000. The increase in capital stock was made necessary by the rapidly growing business of the company. The new factory which was built last summer in Norwood was considered, when built, to be large enough to take care of any expansion in business, but will not handle the present business. Work will be started upon two new buildings as soon as the weather permits.

The Tidewater Oil Company, New Jersey, has increased its capital from \$30,000,000 to \$40,000,000.

The Semet-Solvay Company, Milton Avenue, Solvay, N. Y., manufacturer of coke and by-products, has increased its capital from \$10,000,000 to \$20,000,000 for expansion.

HARRISON BROS. & COMPANY, INC., Philadelphia, Pa., has been sold to the E. J. du Pont de Nemours & Company. The sale was approved at a recent meeting of the stockholders. The companies are both very old ones, the Harrison company starting in 1793 and the du Pont company in 1802. The paint and varnish business of the Harrison company will be continued and expanded. The Harrison plant is on Gray's Ferry Road, on the Schuylkill River. It covers forty acres. The company also controls the Mantua Chemical Company of Paulsboro, N. J., and owns a plant at Camden, N. J. The price paid by the du Ponts was \$5,700,000. The company will have a new name, Harrisons, Inc., of which the incorporators are Lamont du Pont, Dr. Charles L. Reese and Charles A. Meade of the du Pont company; A. R. Glaney and William Richter of the Harrison company.

THE BARRETT COMPANY, 17 Battery Place, New York, held a special meeting of stockholders Friday, March 16, in Jersey City, and voted to increase the authorized capital stock from \$20,000,000 to \$27,500,000.

The company reports for the twelve months ended December 31 last gross income from all sources \$9,547,604, an increase of \$2,894,965. The net increased \$2,044,182.

William Hamlin Childs, president of the company, pointed out to the stockholders that in addition to the usual 7 per cent cash dividends on the common stock there were extra dividends of 7 per cent and of 10 per cent disbursed in July and in December last, respectively. The total sales of the Barrett Company, he said (aside from its commission business), aggregated \$27,318,797 last year, as compared with \$15,883,910 in 1915. He stated that in all departments, both industrial and financial, the company is in better condition than ever before in its history.

The report for the year ended December 31 last is as follows:

	1916	Changes
Gross income...	\$9,547,604	Inc. \$2,894,965
Total expenses...	4,382,318	Inc. 850,863
Net income...	\$5,165,286	Inc. \$2,044,102
Interest	158,657	Dec. 52,563
Net profit...	\$5,006,629	Inc. \$2,096,665
Reserve, etc. ...	758,737	Inc. 331,943
Net final profit applicable to		
Barrett Co. ...	4,247,858	Inc. 1,765,621
Preferred dividend.	333,249	Inc. 158,249
Bal. for com.	\$3,914,608	Inc. \$1,607,372
Common div'd.	2,817,325	Inc. 1,517,393

Surplus \$1,097,283 Inc. \$89,979
Net earnings after interest and preferred dividend amounted to \$4,664,609 or 41.29 per cent, as against \$2,637,237 or 23.35 per cent in the preceding year, based on the \$11,298,200 of common stock.

Construction and Operation

Alabama

BIRMINGHAM.—The Sloss - Sheffield Steel and Iron Company has made some changes in its management and is expected to erect a by-product coke plant. The company is a large pig iron producer and the erection of a large steel plant is also considered. An inventory is at present being made under the direction of Major J. M. Sewell. Mr. Waddell Catchings was recently elected president. During 1916 the Sloss Company had a great year. Its pig iron production was 71,000 tons greater than any other previous year. There were 300,000 tons more coal produced than in any year of the company's history, and 400,000 tons more than 1915. The coke output was 510,000. The total income of the company was \$2,219,532, as compared with \$909,075 the year before, and the surplus was \$1,521,675, as compared with \$170,638. The profit and loss surplus was \$5,049,866 at the end of 1916.

California

OAKLAND.—The Hammer Bray Company will erect a new building with a foundry for making castings for stoves.

OROVILLE.—U. S. Exploration Co. plans erecting large mill and power plant at its mine in Granite Basin this summer.

Connecticut

STAMFORD.—The Connecticut Smelting and Foundries Company has completed a new smelter at Springdale. The apparatus and machinery, however, has not been installed.

Delaware

WILMINGTON.—The plant of the Mineral Products Manufacturing Company has been sold to Taber-Davidson Company, which will manufacture fibre products. The material is not a competitor of the vulcanized fibre, but a supplementary product. The property purchased consists of three and one-half acres containing a large building. Additions have been started and construction will go ahead promptly. The officers of the Taber-Davidson Company are H. P. Taber of the Taber Laboratories Corporation, president; Milton D. Davidson, vice-president; Chas. A. Rudolph, treasurer; Chas. E. McCarroll secretary. The material is called die-cast fibre and is claimed to require no machinery. The material is used for insulation and other purposes.

Florida

TAMPA.—The Export Railway Company is planning the establishment of a phosphate mining plant on Hillsborough Bay, which will cost \$1,000,000. The plant will be complete in one year. The American Mining and Phosphate Company, a subsidiary, will develop a tract of 275 acres near Bloomingdale. The total capacity of the phosphate plant will be 200,000 tons a year.

Illinois

PEORIA.—The new open hearth steel plant of the Keystone Steel and Wire Company is nearing completion. The new plant will require more than five hundred men in addition to what are employed at the old works. The new plant will be modern in every respect.

Louisiana

NEW ORLEANS.—The Louisiana Fibre Board Company is planning to enlarge its plant in order to double the capacity. The Bogalusa Paper Company has ordered \$1,500,000 worth of machinery, which will be installed during the next three months. The two plants will then represent an investment of \$4,000,000 at Bogalusa. Eventually 400 men will be employed at this plant. Mr. G. H. Wood is president of the River Raisin Paper Company, vice-president of the Louisiana Fiber Board Company of Bogalusa.

Maryland

BALTIMORE.—National Enameling & Stamping Co., 1901 Light Street, has plans prepared for erecting 4-story building of brick and steel on Light and Well Streets; cost about \$60,000.

BALTIMORE.—The Standard Guano Company will erect an acid phosphate plant on Curtis Bay, which will turn out 1000 tons of acid phosphate per day. It is reported that the company recently received an order for 2,000,000 tons of the material from the Dutch Government. The company has already a plant in operation and is manufacturing glue and greases. Another plant is planned and will have an output of 100,000 tons of grease per month. This plant will cost \$100,000.

Massachusetts

PITTSFIELD.—A large tract of woodland has been sold to the Caanan, Conn. wood alcohol works; the land is in Lee and Washington and contains many acres.

Michigan

MUSKEGON.—The Lakey Foundry & Machine Co. was recently purchased by Detroit and Moline capitalists and has increased its capital from \$70,000 to \$100,000. A new foundry will cost \$200,000.

Missouri

ST. LOUIS.—The Fulton Iron Works has been constructing a large forge works in the Wellston district. The company is a large manufacturer of sugar mills. It also has the rights to manufacture Diesel engines.

ST. LOUIS.—A large company is contemplating the location of a copper smelter in St. Louis. St. Louis is considered as the only interior center at which the smelter could be located. The industrial department of a St. Louis Railroad is negotiating with this company.

Montana

BAKER.—The Gas Products Company of Minneapolis, Minn., will erect a plant for the manufacture of carbon black. About 125 men will be employed. Baker has been selected as the site for the plant because of the immense quantities of natural gas that exist here.

Nevada

CARSON CITY.—A bill has been introduced at the assembly providing for a State smelter to cost \$500,000. The smelter will be known as the Nevada State Smelter and will treat ores when the owners are not able to build their own smelters.

New Jersey

ELIZABETH.—The Singer Manufacturing Company will erect an addition to its foundry which will cost \$60,000.

LINDEN.—Reported Grasselli Chemical Co. plans erecting 200 x 40-ft. addition to present plant, to cost \$63,000.

NEWARK.—The Newark Wire Cloth Company, Inc., 244 Verona Avenue, Newark, N. J., has purchased property at 848-54 Mt. Prospect Avenue, for a new 4-story plant, 100 x 125 ft., estimated to cost \$50,000. John C. Campbell is president.

NEWARK.—The North American Copper Co., with offices at 52 Vanderbilt Avenue, New York City, has purchased land on the Newark meadows for the erection of a copper refinery. Construction work will not be started for several months.

PASSAIC.—The Manhattan Rubber Mfg. Company, Willett Street, Passaic, N. J., manufacturer of mechanical rubber goods, has filed plans for an addition to cost \$140,000.

New York

BROOKLYN.—The Meurer Steel Barrel Company, 567 Flushing Avenue, Brooklyn, N. Y., has increased its capital stock from \$350,000 to \$650,000 to provide funds for its increased capacity. The company recently put up two new buildings at its plant at Long Island City. Jacob Meurer is president.

FORT EDWARD.—The International Paper Company has commenced the erection of an acid plant to cost \$70,000.

SYRACUSE.—The Halcomb Steel Company will erect two additional furnaces at its plant here. The company has three electric furnaces in operation and this will make five altogether.

North Carolina

WATEREE.—The Southern Power Company has awarded a contract to the Hardaway Contracting Company for the construction of a hydroelectric plant, which will represent an investment of about \$6,000,000. The contract was awarded by J. B. Duke for the Southern Power Company.

Ohio

CLEVELAND.—C. F. Mitchell & Son, Cedar Avenue and East 65th Street, makers of automobile sheet metal parts, contemplate erecting plant on East 131st Street; cost \$250,000.

FINDLAY.—The Findlay Steel Castings Company, a \$200,000 corporation, has purchased the old plant of the Grant Motor Co., which recently removed to Cleveland. The Findlay company will manufacture steel castings by electricity. The officers of the company are E. J. Edwards of Detroit, Mich., president; E. T. Pelton of Milwaukee, secretary, and Dr. C. H. Gage of Oakland, Cal., chemist.

KENTON.—The Champion Iron Company has been reorganized and plans have been made to finance the concern on a much larger scale. Important factory improvements will be made.

LIMA.—The Ohio Steel Foundry Company has awarded a new contract for the construction of a new machine shop to cost \$25,000. The company originally purchased a plant at Bucyrus and is also negotiating for a foundry at Springfield.

MOUNT GILEAD.—Detailed plans are now completed and in the course of execution for rebuilding the burned portion of the plant of The Hydraulic Press Mfg. Co., on its present site in Mount Gilead, Ohio. The plans also include the erection of two additional buildings, which will give more adequate manufacturing facilities. The plans cover the erection of four complete new buildings, consisting of a machine shop, a three story stock room, a new power plant and a structural and forge shop. The machine shop and stock room are replacements on a much larger scale of the portion of the plant recently destroyed by fire. Considerable equipment has been purchased, but much more will be needed. The new machine shop will be 200 ft. long and 100 ft. wide and of fireproof construction. An electric traveling crane of 20 tons' capacity will be located in the center portion of the building and operate on a track running the entire length of the structure. This equipment will give adequate facilities for lifting and moving heavy castings of hydraulic machinery in the course of their manufacture. Two smaller electric cranes of three tons capacity will be operated in each side wing of the building. In addition to the new crane equipment considerable other new machinery will be installed, consisting in part of boring mills, milling machines, lathes, planers, etc. A new power plant will also be erected. This building will occupy a space of 42 ft. x 60 ft. It will be of fireproof construction. For furnishing the power a new 300-hp. Corliss engine will be installed. A 300-hp. water tube boiler, equipped with an automatic stoker will be part of the new power plant equipment. The present power plant of the company will remain intact so that it can be used in case of emergency or as an auxiliary. For fabricating their structural steel this company plans to erect a structural and forge shop immediately east of the present erecting shop. This building will be 50 ft. x 60 ft. An adequately equipped forge shop will be located in this building. Cut-off saws and other equipment will be installed in this new building. Ground is already broken for the new power plant. Work on all buildings will begin immediately and vigorously pushed to completion. It is planned to have the new buildings in full operation by July 1.

STEUBENVILLE.—The Labell Iron Works has under consideration the erecting of a \$5,000,000 steel mill just south of the

company's coke ovens in Brooke County. The report is unconfirmed as yet. Stockholders of the company held a meeting about the middle of March, at which President R. C. Kirk reported that the earnings of the company for the calendar year 1916 were close to \$6,000,000. The resolution offering the plant to the government in time of war was unanimously adopted. The company produced 112,985 net tons of coal from the beehive ovens during the year. The progress made in the construction of the 94 by-product ovens of 12½ tons capacity was disappointing. It was hoped that this plant would be in operation by the beginning of the fourth quarter. It is now expected that they will be in operation very shortly.

Oklahoma

TULSA.—The Prest-O-Lite Company is remodeling the large building formerly occupied by the Needlesha Glass Company, and will install machinery for the manufacture of dissolved acetylene. Mr. A. F. Brennan will have charge of this factory.

Pennsylvania

CHESTER.—The Chester Paper Company will install the largest paper machine in the country. It is now being shipped on 33 cars, and when assembled will turn out paper 147 in. wide.

CHESTER.—The Scott Paper Company of Philadelphia is planning the removal of its entire plant to the site of its branch factory here. Proposed extensions and additions are planned which cost \$500,000.

EASTON.—Dr. Frank Bryon Morse, head of the Radium Chemical Company of New York, was guest at a luncheon at the Rotary Club here on March 5. The Radium company has decided to locate a plant in Easton for the manufacture of radium splendor. The company has large contracts for this material in Europe, and has a plant at Boston.

MARCUS HOOK.—The General Chemical Company, 25 Broad Street, New York, is making rapid progress in the erection of its new plant at Marcus Hook, Pa. The buildings for the most part are three and four-story structures, averaging from 100 x 200 to 600 ft. in size. It is said that four or five of the new buildings will be used by the Baker Adamson Company, a subsidiary.

NEW CASTLE.—The Pennsylvania Engineering Works will erect a large steel plant for the Tanta Iron & Steel Company. The plant will be erected here and then shipped to a site near Calcutta, India. It will include one 1300-ton metal mixer, two 25-ton converters, and one 200-ton rolling open-hearth furnace.

PHILADELPHIA.—Charles Lennig & Co., Inc., 112 South Front Street, Philadelphia, manufacturer of nitric and mixed acids, will build a new one and two-story plant, 40 x 70 ft. and 20 x 20 ft. respectively, at Bridesburg. Plans now being prepared.

PHILADELPHIA.—The Asbestos Products Company, Philadelphia, has been incorporated with a capital of \$24,000 to manufacture asbestos goods. H. R. W. Smith, Norristown, is the principal incorporator.

PHILADELPHIA.—Contract will soon be let for erecting one, two and four story brick and reinforced concrete, 60 x 320-ft. factory building for American Metal Company. Kern Dodge, engineer.

PITTSBURGH.—The Pittsburgh Plate Glass Company, Pittsburgh, is reported planning the erection of a new plant near Sherman Avenue, Newark, N. J., to cost \$100,000. Application has been made to the local board of works to grant permission to the Lehigh Valley Railroad to extend its line to accommodate the proposed works.

The extraction of gasoline from natural gas is increasing in all sections where oil and gas are produced. In the old districts where producers have only a few wells they find it profitable to install a plant and derive as much revenue from the gasoline as the oil production. The production is sold principally to the refiners and the price ranges from 18 to 20 cents a gallon. The United Fuel Gas Company, a subsidiary of the Columbia Gas & Electric Company, is the largest producer in the eastern fields. For the months of January and February this company claims to have made 1,929,048 gal. of gasoline. The Hope Natural Gas Company is the next largest, with a production of from 30,000 to 35,000 gal. a day. Other companies with not so large a production are: Carter Oil Company, 10,000 to 12,000 gal.; People's Natural Gas Company, 10,000 gal.; West Virginia Central Gas Company, 3000 gal.; Reserve Gas Company, from 8000 to 10,000. The Philadelphia Company is installing five large plants in West Virginia and the Manufacturers Light & Heat Company three.

In southeastern Ohio and southwest Pennsylvania there are many plants building. The production of gasoline from natural gas promises to be double that of last year. Many operators who have installed gasoline plants claim that the gasoline recovered from casinghead gas is of a value to not only pay all of the overhead charges for operating the oil wells and a profit besides. Wells so light in oil production as to make almost unprofitable to operate still have a good volume of gas that can be converted into gasoline.

Texas

SAN ANTONIO.—Under the new corporation laws it is believed that it will be possible for the largest oil corporations, including the Standard, Pierce and others, to re-enter the Texas field. They planned to spend several millions of dollars in improving their facilities in this state. Pierce-Fordyce Oil Association contemplates spending at least \$1,000,000 in enlarging refineries.

Utah

SALT LAKE CITY.—The Garfield copper smelting plant of the American and Refining Company will be enlarged in order to increase the capacity by 40 per cent.

The Murray lead and silver smelter will also be greatly enlarged, as it is running to capacity at present at 1000 tons per day.

Virginia

NORFOLK.—The Mexican Petroleum Corporation has been authorized to do business in the State of Virginia. The capital stock of its Virginia business is \$2,000,000. The company recently purchased property along the southern branch of the Elizabeth River and will shortly commence the erection of a large plant.

Washington

SEATTLE.—The American Glass Company, which started its business here six months ago, has developed into a strong manufacturing concern. The company has a modern plant, and while it does not manufacture glass it prepares same for commercial use on a large scale. The company has developed a large export trade.

SEATTLE.—The Arizona Smelting & Refining Company is planning the manufacture of ferro-alloys. It will obtain manganese ore from Japan and expects to make ferro manganese, ferro chrome, and ferro tungsten. A temporary plant is located at 945 Ewing Street, Seattle. It is expected to erect a permanent plant in the near future.

SEATTLE.—The U. S. Bureau of Mines Station here will have a force of nine men. It will also have one man, Mr. J. A. Davis, at Fairbanks, Alaska; one or two men at Moscow, Idaho, at the university there, and two men at Corvallis, Ore., at the State College.

SEATTLE.—The Pacific Metal & Galvanizing Company has been recently organized in Seattle. The company will construct a plant at Hanford Street and Whatcom Avenue. The first unit will consist of equipment for galvanizing by hot dip process with a capacity of 5000 tons per annum. The officers are: President, C. B. Rhodes, formerly assistant to president of Seattle Drydock & Construction Company, and Henry L. Gray, secretary and treasurer.

SEATTLE.—Rothert Steel Process Company is installing a 2-ton Wile furnace in its plant at South Seattle. The company will manufacture high-grade tool steel from titaniferous ore. It is planned to later install three 10-ton furnaces.

West Virginia

RICHWOOD.—The William F. Mosser Company will enlarge its tannery at a cost of \$250,000.

Wisconsin

MILWAUKEE.—The Federal Pressed Steel Company has purchased five and one-half acres on Booth and North Pierce Streets, which will double its present acreage.

The Wisconsin Metal Refining Company has moved into its new plant at Fratney and Franklin Streets.

OSHKOSH.—Joseph Hanser of Milwaukee has established a plant for the manufacture of potash from wood ashes.

Manufacturers' Notes

B. F. STURTEVANT COMPANY of Boston, Mass., has just completed manufacture of special equipment for the China-American Products Company of Shanghai, China. The equipment consists of a large tank connected to exhauster, and is used for drying eggs. The eggs are cracked and shells removed, and the contents poured on trays which are placed in the tank and hot air is passed over them, absorbing the moisture. The apparatus has capacity of 800 eggs per hour. The dried product is canned and exported to U. S. A.

TAKAMINE LABORATORY INC., 120 Broadway, New York City, has been appointed the sole distributing agent in the United States and Canada, of the products of the Japanese government's dyestuffs works. Dr. J. Takamine has been appointed on the board of directors.

NEW DIRECTORS IN INDUSTRIAL ALCOHOL.—At the annual meeting of the stockholders of the United States Industrial Alcohol Co., Edward W. Harden, E. W. McKenna, W. S. Kies and R. P. Tinsley were elected directors in place of Frederick S. Flower, Crawford Livingston, Julius Kessler and James P. McGovern, resigned. With these exceptions the retiring directors were re-elected. One of the officers of the company made the following statement: "in view of the increasing importance of the company's export business and because of the foreign trade facilities and organization of the American International Corporation, two officers of that concern, Messrs. Kies and Tinsley, were invited to membership on our board. Mr. Harden is connected with the banking firm of James B. Colgate & Co., and is a brother-in-law of President Vanderlip of the National City Bank. Mr. McKenna is an engineering expert."

BRADFORD DYERS' ASSOCIATION MEETS.—The annual meeting of the Bradford Dyers' Association (Ltd.) was held in Bradford, England, on February 27. The chairman had the following to say concerning the British dyestuff industry.

"After two and a half years of war, so far from our industries having collapsed, they are in a more flourishing condition than in any previous period of our history; but great as has been the progress in the manufacture of aniline colors in this country, and creditable though it is to those engaged in such manufacture, it might unquestionably have been greater, in spite of the prior claim on many materials for the manufacture of explosives, had the course been followed which the accredited representatives of practically all the color users in the United Kingdom and Ireland have insistently and persistently urged upon the color-making companies, namely, the consolidation of all their interests in one company, thus preventing overlapping and waste of effort. Instead of this, we have seen three such companies employing on the same problems their cleverest chemists, whose activities by a co-operative arrangement would have been spread over a wider field of research. The result is that at the present time two of the concerns are wasting money in rival advertisements announcing their success in the manufacture of certain colors which were generally supposed to present the greatest difficulties."

"At the same time we learn that a private company in Carlisle, whose only interest in and knowledge of dyes before the war was that of users, seeing its business faced with ruin by its inability to obtain the continental dyes in the use of which it had specialized, determined to make such dyes for itself, and it has entirely succeeded; not only so, but in one color of vital importance it has improved upon the best foreign make. These facts surely are a proof that there are no insuperable difficulties in covering the whole field of color production."

"With an unprecedented output of dyed goods, we can not to-day in one sense be said to be suffering from a lack of dyes. With the exception of America, Great Britain is at the moment the only serious producer of dyed textiles for export, and the abounding prosperity of the American people enables them to consume practically the whole of their production. It follows, therefore, that neutral markets are bound to take the limited range of colors we can offer, greatly to our temporary advantage and profit, as it requires no expert knowledge to appreciate the fact that our gain is great by having to handle, say, 50 shades as compared with six to eight times that number. But immediately the war is over we must be in a position to offer the widest range of colors; otherwise our position will become most serious by placing a great volume of our export trade in jeopardy."

One point vitally important to the future prosperity of the aniline-dye industry was the need of securing the most ample supply

of benzol at a price which would enable colors to be manufactured as cheaply as in Germany. The chairman therefore urged that the present control by the British Government of the production of benzol should not be relinquished before the fullest safeguards to the dye-making industry have been established, and that without delay some authority should be set up to study closely and report upon the various methods by which benzol is now being produced under the pressure of war demands, with a view of determining authoritatively which is the best. As to the problems arising after the war, the chairman referred to the competition that will have to be met from the United States, Japan, Holland and Germany.

ANTI-ACID VALVES.—The Lunkenheimer Company of Cincinnati, Ohio, state that during the past year, there was an exceptionally great demand for valves made entirely of iron for use in handling cyanides and other solutions which attack metals having copper as their basic element. This company supplied a large number for use in dye and chemical manufacturing plants, but the demand was not confined to these sources as quite a number were also supplied for use in mines, oil refineries, tanneries, pulp and chemical fiber mills, canning and packing establishments, etc.

They maintain large and well equipped chemical and physical laboratories through the aid of which they are enabled to furnish valves and fittings of such materials as best adapt them for the handling of various corrosive solutions.

For use in handling the more severe solutions, such as caustic soda, caustic potash, soda-ash and other similar alkaline liquids the company employs a composition known as "Lunkenheimer Nickel-Iron." This metal has exceptional acid resisting qualities and the long and satisfactory service rendered has led many to use valves made of this material even for the weaker solutions.

A. J. CORCORAN, INC., Jersey City, N. J., will remove its offices on May 1st from 11 John Street, New York City, to the factory at 761 Jersey Avenue, Jersey City. The new offices provide better facilities for handling the business and showing goods.

THE GERMAN-AMERICAN STONEWARE WORKS, 50 Church Street, New York City, has changed its name to the General Ceramics Company.

Manufacturers' Catalogs

N. Y. REVOLVING PORTABLE ELEVATOR CO., 379 Garfield Avenue, Jersey City, N. J., has issued Bulletin No. 50 entitled "The Revolver." It describes the company's portable elevator or tiering machine with a revolving base, for use in piling barrels, boxes, etc.

SCHAAR & COMPANY, Chicago, Ill., have just issued a catalogue for exclusive use of universities and colleges containing glassware and porcelain which they are now able to import on the "duty free" basis. This catalogue is unique in that it is the first time in the history of the apparatus business that a catalogue has been issued solely for "duty free" importations.

THE SOLVAY PROCESS COMPANY, Syracuse, N. Y., has issued a very interesting booklet entitled "Solvay Alkalies." It gives a short history of the various alkali products produced by this company, illustrations of the various plants, notes on alkalimetry, and chemical and commercial tables conveniently arranged.

THE DIAMOND POWER SPECIALTY COMPANY, Detroit, Mich., has issued Bulletin 117, entitled "Increasing To-Day's Profits." This bulletin describes the company's soot blowers. Bulletin 125 has also been issued, describing Diamond Soot Blowers for Babcock & Wilcox Boilers.

THE LINK-BELT COMPANY, Chicago, Ill., has issued Book No. 120, describing the Peck Carrier for coal, coke, ashes, cement, sand, stone, ore and other materials.

THWING INSTRUMENT COMPANY, 3339 Lancaster Avenue, Philadelphia, Pa., has issued a bulletin describing pyrometers for clay burners.

Other New Publications

COBALT, MOLYBDENUM, TIN, TITANIUM, TUNGSTEN, RADIUM, URANIUM AND VANADIUM IN 1915. By Frank L. Hess. This is issued by the Department of the Interior, Washington, D. C.

ARTIFICIAL GAS AND BY-PRODUCTS IN 1915. By C. E. Leshar. Issued by the Department of the Interior, Washington, D. C.

GOLD AND SILVER IN 1915 (General Report). By H. D. McCaskey and J. P. Dunlop. Issued by the Department of the Interior, Washington, D. C.